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NORTH CAROLINA GEOLOGICAL AND ECONOMIC SURVEY

JOSEPH HYDE PRATT, STATE GEOLOGIST

BULLETIN No. 22

CID MINING DISTRICT OF DAVIDSON COUNTY

NORTH CAROLINA

BY

zekiel

JOSEPH E. POGUE, Jr., Ph. D.

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GEOLOGICAL BOARD.

LETTER OF TRANSMITTAL.

CHAPEL HILL, N. C., June 1, 1910.

To His Excellency, HON. W. W. KITCHIN,
Governor of North Carolina.

SIR: A report has just been completed by Dr. Joseph E. Pogue, Jr., on The Cid Mining District of Davidson County, North Carolina, and I would recommend that this report be published as Bulletin 22 of the publications of the North Carolina Geological and Economic Survey.

This report covers a geological investigation of the Cid mining region and is a continuation of the study of the geological formations of Piedmont North Carolina that was begun in the Gold Hill Mining District, the results of which were published in Bulletin 21.

Yours respectfully,

JOSEPH HYDE PRATT,
State Geologist.

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INTRODUCTION.

The following report is a geologic and economic investigation of the Cid Mining District of Davidson County, North Carolina, an area covering about 125 square miles. It also gives a detailed study of the occurrence and origin of the copper, silver and gold deposits included within the district, and description of all the mines that have been operated.

This investigation shows that the "veins" or ore deposits may be grouped into four classes: (1) impregnations of ore in the schists; (2) stringer leads, ranging from intricating stringers and lenses of quartz to well-defined quartz veins, and agreeing in trend with the schistosity or cutting that structure at small angles; (3) cross veins, or well-defined quartz veins, which cut the schistosity at large angles and are usually barren; and (4) replacement deposits, or zones carrying seams and lenses of ore, chiefly argentiferous and auriferous galena and sphalerite, in an extremely metamorphosed or highly silicified country rock.

Chapter I gives a geographical and historical sketch of the district. Chapters II and III discuss the general geology of the district and give a detailed description of the rocks. Chapters IV and V relate to the physiography of the district and discuss very thoroughly the problems relating to structure and metamorphism. Chapter VI is a detailed description of the mines and prospects in the district, followed by a discussion regarding the genesis of these ore deposits. The results obtained in the investigation are summarized in Chapter VII.

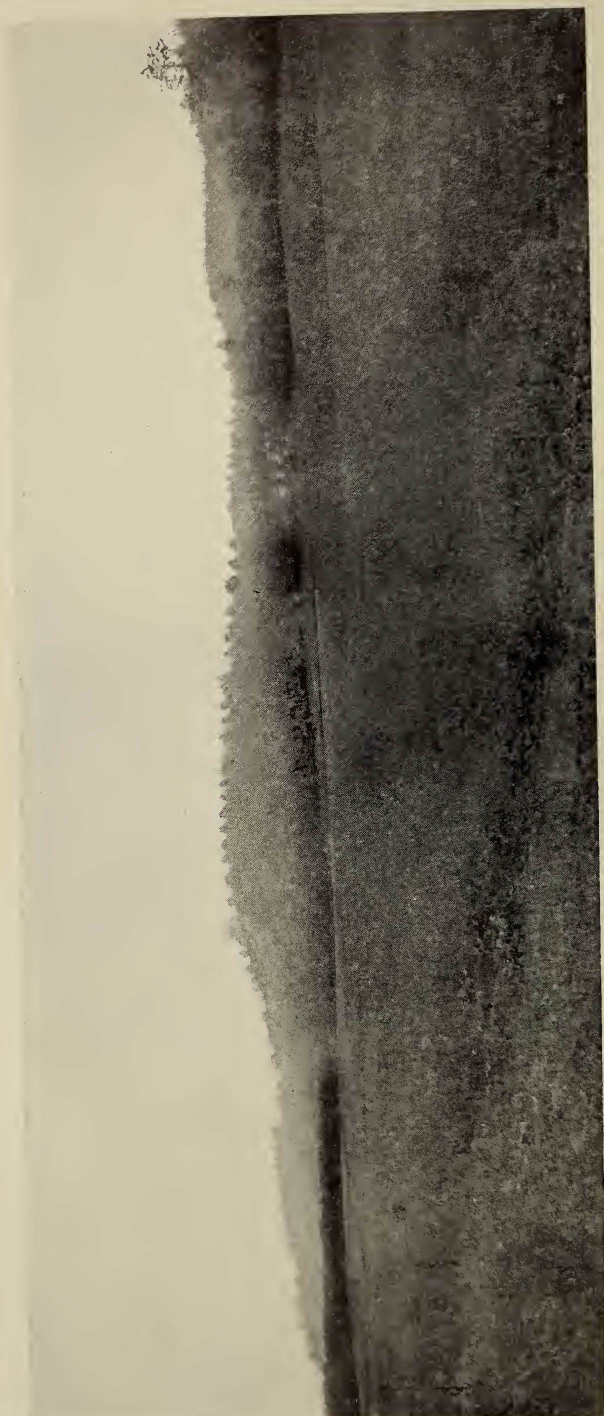
There is an appendix to the report which gives a bibliography of the Cid Mining District.

This report has been prepared by Dr. Joseph E. Pogue, Jr., who did the field work in 1908 and conducted the laboratory investigations in the Petrographical Laboratory of Yale University. The traverse map, which has been used as the base of the geological map, was made by Mr. R. L. Harrison, of the U. S. Geological Survey.

The author and State Geologist wish to acknowledge their indebtedness: To Mr. O. L. Stoner, of Linwood; to Messrs. J. A. Shirley,

J. A. Prim and J. F. Peters, of Silver Hill, and to Messrs. O. O. Robinson, A. J. Beck, W. Cockreham and Alex. Hedrick, of Cid, for information and courtesies extended during the course of the field work; to Dr. F. B. Laney, for looking over the field work, for numerous suggestions, and particularly for his previous work in the Piedmont Plateau; to Mr. D. B. Sterrett, for taking some photographs of rock specimens for the author; to Prof. Joseph Barrell, for suggestions and for a critical discussion of the main ideas presented in the chapter on structure and metamorphism; and especially to Prof. L. V. Pirsson for his kindly interest and help at every stage of the investigation.

JOSEPH HYDE PRATT,
State Geologist.



FLAT SWAMP MOUNTAIN, FROM THE EAST, DAVIDSON COUNTY, N. C.

THE CID MINING DISTRICT OF DAVIDSON COUNTY
NORTH CAROLINA

By Joseph E. Pogue, Jr.

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CHAPTER I.

GEOGRAPHY AND HISTORY.

GEOGRAPHICAL SKETCH OF CID MINING DISTRICT.

Location.—The area described in this report is a part of Davidson County, North Carolina. It is situated in the central portion of the State, within the Piedmont Plateau, and near the western boundary of an area of volcano-sedimentary rocks known as the "Carolina slate belt," which crosses the State in a northeast and southwest direc-

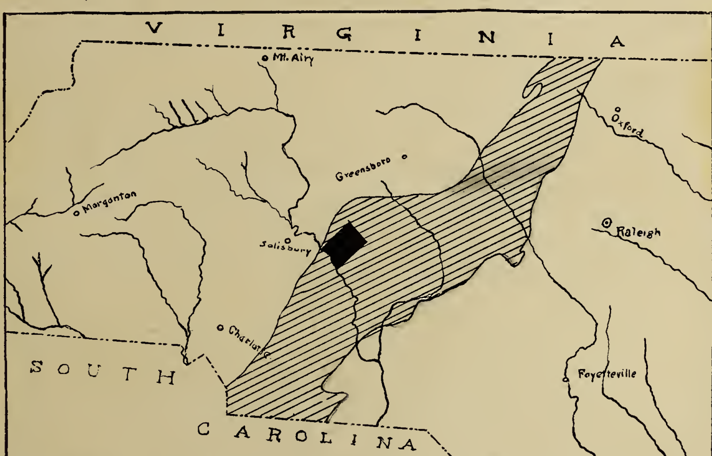

Fig. 1—Index Map showing the location of the Cid Mining District (in black) and the "Carolina Slate Belt" (shaded).

tion. The tract is about 13 miles long and 9 miles wide, covers approximately 125 square miles, and extends northeast from the Yadkin River, which forms its southwestern boundary, 1 mile beyond the village of Cid. (See Fig. 1.) On the southeast it includes the villages of Jacksonhill and Denton; on the northwest, Fairmont and Silver Hill. The area is reached on the Carolina Central Railroad, a small branch line connecting with the main line of the Southern Railroad at Thomasville, and extending from that point through Cid to Denton, a distance of 20 miles. Not more than a dozen miles distant are Gold Hill, Thomasville, Lexington, and Salisbury.

Topography.—Though a part of the Piedmont Plateau, the area in places is quite rugged. The chief surface feature is Flat Swamp Ridge, a narrow ridge which rises about 200 feet above the neighboring valleys and extends for nearly 7 miles through the central portion of the district. This ridge consists of Flat Swamp, Grice, and Surratt "mountains," and forms the backbone of a region which slopes into gently rolling country on either side. To the north the area is a succession of narrow ridges and rounded eminences, the more important of which are Kemp and Three Hat mountains; the latter extending beyond the area mapped. In the southern corner, the country rises considerably to a conical-shaped hill, known as Bald Mountain, which is not included in the region described. The gently rolling country, though not so striking as the ridges, is quantitatively more important, and presents the usual well-rounded hills and gentle slopes typical of maturely dissected regions.

Drainage.—The area is drained by the Yadkin River, which flows directly across it and cuts a narrow passageway through Flat Swamp Ridge. Of secondary importance are Abbott's Creek, Flat Swamp Creek, Lick Creek, and Cabin Creek, which pursue almost parallel courses, until they enter the river at nearly right angles to it. The network of smaller watercourses in general fails to show the regular arrangement of the more important streams.

Soil.—The soil for the greater part is lean and not first-class farming land. Once covered by a heavy growth of timber, which has been thinned by man and the devastation of forest fires, it now carries on the rougher portions a scant and scraggy covering of second growth timber, while the gentler slopes are mostly cleared and in part under cultivation. The ridges are extremely rocky; in certain places numbers of huge rocks abound, which have been not inaptly compared to "cockade hats" on account of their narrow, elongated outline.

Climate.—The climate is equable and agreeable for nearly the entire year. The mean annual temperature is about 58° Fahrenheit; the average yearly precipitation is about 51 inches, and well distributed throughout the year. The region is free from prolonged droughts in the summer, as well as from excessive rain and snow in the winter.

Culture.—The country is sparsely populated, and for the greater part by those who trust in the output of small farms for their livelihood. There are no large landowners, yet most of the inhabitants are independent and some sub-let a portion of their farms to tenants. Though too little attention has heretofore been directed toward bettering the schools, churches, and roads, the people are hospitable, favorable to outside interests calculated to develop their resources, and are paying more and more attention to features which make for social and economic improvement. The mining industry, formerly of importance, does not at present (1908) add to the activity of the region.

PREVIOUS GEOLOGIC WORK.

No detailed geological work has been previously done within the area embraced in the present report. The mines, however, from time to time received the attention of certain geologists and mining engineers, and mineralogists were interested in various finds of rare minerals. Other portions of the Carolina slate belt, on the other hand, have been the field of much investigation, and such views and results of the workers therein as have a general application to the area in hand will be here developed.

In 1799 there appeared in the *Medical Repository* a letter by James Hall,[1] descriptive of a supposed artificial wall about 14 miles from Salisbury near the Yadkin River; with a reply by James Woodhouse to the effect that the wall was composed of basalt. This was followed by no less than seven articles or letters, in addition to various notices, in which the wall was attributed twice[2, 3] to antediluvian man and five times[4, 5, 6, 7, 8] to igneous agency. These ar-

[1]Hall, James. An account of a supposed artificial wall discovered under the surface of the earth in North Carolina. In a letter to James Woodhouse (and Doctor Woodhouse's reply). Med. Repos., v. 2 (1799): 272–278.

[2]Lewis, Zachariah. Letters on subterranean wall on the Yadkin in North Carolina. Med. Repos., v. 5 (1802): 397–407.

[3]Beckwith, John. A memoir on the natural walls or solid dikes in the State of North Carolina. Am. Jour. Sci., Ser. I, v. 5 (1822): 1–7.

[4]Lewis, Zachariah. Remarks on a subterranean wall in North Carolina. Med. Repos., v. 4 (1801): 227–234.

[5]Woodhouse, James. Remarks on a letter of the Rev. Zachariah Lewis relating to a subterranean wall discovered in North Carolina. Med. Repos., v. 5 (1802): 21–24.

[6]Woodhouse, James. Additional observations on the subterranean minerals near the Yadkin in North Carolina. Med. Repos., v. 7 (1804): 26–27.

[7]Ayres, Stephen. A description of the region in North Carolina where gold has been found. Med. Repos., v. 10 (1807): 148–151

[8]Cooper, Thomas. Floetz trap in North Carolina. Am. Jour. Sci., Ser. I, v. 4 (1822): 241.

ticles are of interest because they represent the earliest accounts of geological phenomena in central North Carolina.

In 1825 the first geological exploration of the country, including and adjoining the Cid District, was undertaken. In that year Olmsted,[1] recently appointed State Geologist of North Carolina, called attention to the "great Slate Formation" which "passes quite across the State from northeast to southwest, covering more or less of the counties of Person, Orange, Chatham, Randolph, Montgomery, Cabarrus, Anson, and Mecklenburg." He describes this formation, which is about 20 miles wide, as consisting principally of parallel ranges of Clay Slate or Argillite, occurring in perpendicular slabs of various complexions; together with numerous beds of petrosiliceous porphyry, soapstone, serpentine, green-stone, and whetstone slate or novaculite. The different members are described in but little detail. While the "slates" are recognized as differing from ordinary slates, no explanation for this variation is given. Mention is also made of the occurrence of placer gold within the slate belt.

In 1828 Rothe[2] attempted a fanciful explanation of this alluvial gold. He attributes its widespread occurrence to a great inundation "perhaps occasioned by the breaking through the Blue Ridge of waters accumulated on the other side," and their re-accumulation above the Narrows of the Yadkin, with the resulting deposition of the gold previously removed from veins by the force of the waters. The following year Mitchell,[3] in a more important paper than the preceding, recognized that "no stratum, except derived from rock decomposition, covers the upper country," and that the rock itself is the source of the gold through weathering. He further calls attention to a member of the slate formation not mentioned by Olmsted: namely, a "conglomerate or breccia * * * sometimes exhibiting a schistose structure and sometimes destitute of any tendency to such a structure," which occurs in alternate layers with the slate. He emphasizes, moreover, the great diversity in appearance of the various phases of the argillite. In 1830 Eaton[4] added the term "talcose slate" to those already used in describing the members of the slate belt; speaking of it as occurring in association with novaculite.

[1] Olmsted, Denison. On the gold mines of North Carolina. Am. Jour. Sci., Ser. I, v. 9 (1825): 5–15. Report on the geology of North Carolina, conducted under the Board of Agriculture. Raleigh, J. Gales & Son. 1825–27.

[2] Rothe, Charles E. Remarks on the gold mines of North Carolina. Am. Jour. Sci., Ser. I, v. 13 (1828): 201–217.

[3] Mitchell, Elisha. On the geology of the gold region of North Carolina. Am. Jour. Sci., Ser. I, v. 16 (1829): 1–19.

[4] Eaton, Amos. The gold of the Carolinas in talcose slate. Am. Jour. Sci., Ser. I, v. 18 (1830): 50–52.

Little work was done for the next ten years. In 1841 Hodge[1] attributed the concentrically weathered Piedmont boulders to glacial action, and mentioned the passage downward of the gold ores of Davidson County into undecomposed sulphurets. In 1842 Mitchell[2] added little to what was already known of the slate belt. He recognized, in addition to argillite, hornstone, flinty slate, and jasper, interstratified beds, sometimes massive and sometimes exhibiting a "slaty structure," composed of water-worn, siliceous and other pebbles, united by a cement of silica. He mentions the occurrence in Davidson County of patches of "those rocks, by which a passage is made from slate to granite, these * * * often colored green by epidote."

In 1854 Leeds[3] spoke of the rocks of the gold region as "trappean belts of country * * * and ranges of hornstone slate" seemingly forming parallel bands. The trappean rocks include greenstone, hornblendic granite, feldspathic granite, syenitic granite, and a siliceous sub-crystalline rock, closely allied in its external characters to hornstone.

Thus the matter rested, until Emmons[4] in 1856, in his "Geological Report of the Midland Counties of North Carolina," developed the following views, representing the results of the most important work thus far done. He considers the slate belt composed of:

"Slates and siliceous rocks which have been called quartzites. * * * The slates are variable in color and composition. They are mineralogically clay, chloritic, and talcose slates, taking silica into their composition at times, and even passing into fine grits or hornstones, but still variable in coarseness. In the order in which they lie, the talcose slates and quartzites are the inferior rocks, though quartzite occurs also in the condition of chert, flint or hornstone, in all the series."

That the slates are sediments is considered proved by the occurrence of "numerous beds containing rounded pebbles." Moreover, the adjacent granite is mentioned as the source of the sediments. A "brecciated conglomerate" is described as a "most remarkable"

[1]Hodge, James T. The boulders and deposit gold mines of North Carolina. Assoc. Am. Geol. and Nat., Repts. of 1st, 2d and 3d meet. (1841): 34, 35, and Am. Jour. Sci., Ser. I, v. 41 (1841): 182, 183.

[2]Mitchell, Elisha. Elements of geology; with an outline of the geology of North Carolina. 1842. With map.

[3]Leeds, Stephen P. Notes on the gold regions of North and South Carolina. Min. Mag., Ser. I, v. 2 (1854): 27–34; 257–269.

[4]Emmons, Ebenezer. Geological report of the midland counties of North Carolina. New York, Geo. P. Putnam. Raleigh, Henry D. Turner. 1856. See also

Emmons, Ebenezer. American Geology. Albany, Sprague & Co. 1855.

member of the series. It is "composed in the main of fragments of other rocks mostly retaining an angular form, but frequently rounded and worn rocks are inclosed in the mass."

The "quartzite" is described in great detail and a variety of rocks are evidently included under this term. It is defined as an "uncrystalline kind of quartz, resembling as closely as possible common gun-flint." There are porphyritic and amygdaloidal phases; the latter not recognized as such, but described as "greenish, and full of cavities, and frequently epidotic." The several varieties are considered to be most probably deposited from solution.

In point of age, the slates are consigned to the "Taconic System"—a term proposed by Emmons to embrace those sediments occurring beneath the Silurian and above the "primary series" of igneous rocks. In support of this correlation is cited the resemblance in position and lithological character to the rocks of the original Taconic System, and also the occurrence of certain nodular or concretionary forms, which are considered fossil sponges and to be "the oldest representatives of the animal kingdom on the globe." To these forms is given the generic name "Paleotrochis," meaning "old messenger," and two species are differentiated, called, respectively, Paleotrochis major and Paleotrochis minor. Subsequent work has shown these interesting forms to be spherulites.[1]

During the next 19 years work was limited to the publication of a few notes on the Silver Hill Mine, an occasional mineralogical notice, and quite a variety of discussions as to the merits of Paleotrochis, which was "proved conclusively" to be of both organic and inorganic origin.

In 1875 Kerr[2] published his "Geology of North Carolina," including a geological map of the entire State. He describes the slate series in practically the same terms as did Emmons, but in less detail and with the exception that they are considered Huronian in age.

"The gold deposits, which are contemporaneous with the slates themselves, are of far greater importance than the true gold veins. * * * The gold in these slate beds, like the slates themselves, is derived from the destruction of the older rocks, and has been deposited simultaneously."

In 1888 appeared Kerr and Hanna's "Ores of North Carolina."[3]

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[1] Diller, Joseph Silas. Origin of Paleotrochis. Elis. Mit. Sci. Soc. Jour., v. 16 (1899): 59-67.
[2] Kerr, Washington Caruthers Report of the Geological Survey of North Carolina. 1875.
[3] Kerr, W. C., and Hanna, G. B. Ores of North Carolina: being chapter II of the second volume of the Geology of North Carolina. Raleigh, Edwards & Broughton. 1888.

This is entirely of an economic nature and does not contribute to the geology of the slate formation. The Conrad Hill and Silver Hill mines are described in some detail, with drawings of the underground workings; but no theories as to the genesis of the ores therein are offered.

In 1894 Williams,[1] in a brief but very important paper, recognized for the first time the occurrence within the slate belt of ancient acid volcanic rocks. He considers that these in the main are altered rhyolites. A sketch map of a portion of Orange and Chatham counties is included, showing locations of volcanic rocks. Of a small area near Chapel Hill, the following description is given: "Here are to be seen admirable exposures of volcanic flows and breccias with finer tuff deposits which have been sheared into slates by dynamic agency." Suggestion is made that the "chert" or "hornstone" of Emmons may be of volcanic origin.

The following year, in 1895, Becker[2] in his "Gold Fields of the Southern Appalachians" described the Carolina Slate Belt, referring it to the Algonkian. He recognizes the volcanic nature of portions of the slate series, speaking of the "porphyries" in the following terms:

"They show flow structures in some cases and were probably in part glassy and tuffaceous rocks, yet they were most likely deeply buried at the time of the formation of the deposits."

The cherts, quartz rocks, hornstones, etc., of former writers are thus described:

"Under the microscope they show small inter-locking grains of quartz looking very much like vein quartz and giving no evidence of growth from fragments, but always mingled with minute scales of muscovite. There seems strong reason to suppose these masses due to decomposition and recrystallization of the acid volcanics."

The greater portion of the gold within the slate is considered to have been deposited at the close of the great volcanic era, or during the Algonkian. Dikes are cited which seem connected with the deposition of the ore; and among others one occurring at the Silver Hill Mine is described thus:

"A dike rock which seems to be a decomposed diabase lay in con-

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[1]Williams, George Huntington. The distribution of ancient volcanic rocks along the eastern border of North America. (With map.) Jour. Geol., v. 2 (1894): 1-31. Also Ancient volcanic rocks along the eastern border of North America. Am. Geol., v. 13 (1894): 212, 213.

[2]Becker, George Ferdinand. Gold fields of the Southern Appalachians. (In U. S. Geol. Survey, 16th Ann. Rep., pt. 3, 1895.)

tact with the ore, as appeared from masses on the dump." These are distinct from later intrusions of Triassic "olivine basalt." A theoretical discussion of the fissures is given.

"If * * * the general tendency in the Southern Appalachians is to overthrust movements, it was a temporary reversal of this tendency which opened the fissure system of this region."

The mode of filling the fissures by means of uprising solutions is considered, and brief descriptions of the Silver Hill, Silver Valley, and Emmons mines are included.

The same year, 1895, Nitze and Wilkins[1] presented a paper in which they maintained that the gold ores of the slate formation are due to the "ascension of heated carbonated and alkaline waters, carrying silica, metallic elements, and sulphides in solution" and deposition in open spaces, by relief of pressure, lowering of temperature, and perhaps chemical reactions.

In 1896 appeared the "Gold deposits of North Carolina" by Nitze and Hanna.[2] These authors identify within the slate series argillaceous, sericitic, and chloritic schists. They distinguish between slates and schists in the following terms:

"A great number of rocks have a true slaty cleavage, while others are more truly schistose; *i. e.,* the laminæ are not essentially parallel. These structural effects are due to the action of dynamic metamorphism on materials of different composition. The argillaceous type might more properly be called the slates * * * as they contain more uncrystalline matter, and possess a more definite slaty structure."

In regard to the origin of these schistose and slaty rocks, they say:

" * * * in part, it seems they must be sedimentaries altered by dynamo- and hydro-metamorphism. * * * It does not seem probable * * * that these slates have been derived from the granitic and other more basic igneous masses lying to the west, for * * * these are supposed to be later intrusive bosses."

The occurrence of volcanic rocks is recognized and noted. The dense siliceous rocks (hornstones, etc., of previous writers) are considered to be most probably devitrified rhyolites. It is suggested that "there was more than one volcanic outbreak, and during at least one period of inactivity slates were deposited." Accompanying the acid

[1]Nitze, H. B. C., and Wilkins, H. A. J. The present condition of gold-mining in the Southern Appalachian States. Am. Inst. Min. Eng., Trans., v. 25 (1895): 661–796.
[2]Nitze, H. B. C., and Hanna, G. B. Gold deposits of North Carolina. N. C. Geol. Survey, Bull. 3, 1896.

volcanics are described "pyroclastic breccias and basic eruptives, which are usually schistose." These are described as follows:

" * * * usually of a dark green color, and perhaps pyroxenic in composition, sometimes prophyllitic; they cover large areas, and are often massive or only partly schistose; again they are largely sheared into schists."

The authors describe a series of sedimentary rocks occurring in Union County in the southeast portion of the Carolina slate belt, which they consider of later age than the slates to the west and north. This new member in the slate series, which is termed the "Monroe Slates," forms "a considerable area of truly bedded and but little indurated or metamorphosed slates."

In regard to the genesis of the ores, the following is in the main the view advanced. A force from the northwest developed normal faulting (this later than the "shearing" force), accompanied by the production of "spaces of discission," which were afterwards filled by uprising ore-bearing solutions. The origin of these deep-seated waters is connected with the "last stages of the volcanic activity that was general * * * ." The silicification of the slates and schists are likewise attributed to the ore-bearing waters. The ore deposits are Pre-Jurassic. Descriptions are included of the Conrad Hill, Silver Hill, Emmons, and Cid mines.

Other articles by Nitze the same year[1, 2] and the following year[3] do not add essentially to the views set forth above. The same may be said of Bulletin 10 of the North Carolina Survey by Nitze and Wilkins.[4]

In 1906 Weed and Watson[5] in a joint paper on the Virgilina copper deposits considered a portion of the slate belt in the vicinity of Virgilina, Virginia. From a study of the schistose rocks occurring in this district, they drew the following conclusions:

"1. The rocks have been greatly altered from pressure and chemical metamorphism, as indicated in the prevailing schistose structure and the large development of secondary minerals. * * * 2. From structural, petrographical, and chemical evidence it is shown that the rocks are derived from an original andesite. * * *

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[1]Nitze, H. B. C. Gold mining in the southern states. Engineering, v. 10 (1895): 821–844.

[2]Nitze, H. B. C. Some late views of the so-called Taconic and Huronian rocks of North Carolina Elis. Mit. Sci. Soc., Jour., v. 13 (1896): 53–72.

[3]Nitze, H. B. C. The genesis of the gold ores in the central slate belt of the Carolinas. Eng. and Mg. Jour., v. 63 (1897): 628–629.

[4]Nitze, H. B. C., and Wilkins, H. A. J. Gold mining in North Carolina and adjacent South Appalachian regions. N. C. Geol. Sur., Bull. 10, 1897.

[5]Weed, Walter H., and Watson, T. L. The Virginia copper deposits. Ec. Geol., v. 1 (1906): 309–330.

3. The rocks are Pre-Cambrian in age and represent an area of ancient volcanic rocks * * * ."

The same views, but in less detail, were put forward in earlier papers by each of the above authors.[1, 2]

In the same year appeared "A Reconnaissance of some Gold and Tin Deposits of the Southern Appalachians" by L. C. Graton.[3] This is economic in nature and deals with an area to the southwest of Davidson County, consequently no descriptions of the mines of the Cid District are included. The gold deposits are divided into two types—fissure veins and replacement deposits—with transitional members. In regard to the genesis of the ores, the following are the summarized views advanced:

"Concentrated solutions containing gold, silica, potash, sulphides, and oxides of iron and titanium ascended from great depths at high pressure and temperature. In the denser rocks they forced their way along crevices, forming veins. * * * In the more porous rocks the solutions permeated large masses and replaced the original rocks fragments. * * * The source of the ore material was at great depth below the surface. * * * It seems certain that the vein solutions are genetically connected with * * * granite intrusions. * * * The deposition * * * was probably due partly to decrease of temperature and pressure * * * but was doubtless caused mainly by a disturbance of the nice equilibrium of solubility and concentration by the accession of substances dissolved from the wall rock."

In April 1908 Eaton[4] published an article on a flint-like slate from near Chapel Hill. A microscopic description is given, accompanied by a partial chemical analysis, and it is concluded "that the rock has remained essentially unchanged since its consolidation, and that its formation was similar to that of an arkose, viz: that its component minerals are the detrital fragments of a rock or rocks rich in quartz and feldspar." This rock is probably the same as the "dense siliceous rocks," "cherts," and "hornstones" of previous writers, and most likely represents a silicified acid tuff.

[1]Weed, Walter Harvey. Types of copper deposits in the Southern United States. Am. Inst. Min. Eng., Trans., v. 30 (1900): 449–504.
[2]Watson, Thomas Leonard. Copper-bearing rocks of Virgilina copper district, Virginia and North Carolina. Geol. Soc. Am., Bull., v. 13 (1902): 353–376.
[3]Graton, Louis Caryl. Reconnaissance of some gold and tin deposits of the southern Appalachians. U. S. Geol. Sur., Bull. 293 (1906).
[4]Eaton, Harry Nelson. Micro-structure and probable origin of flint-like slate near Chapel Hill, N. C. Elis. Mit. Sci. Soc., Jour., v. 24 (1908): 1–8.

The following month Laney,[1] in a thesis presented at Yale University, on the Gold Hill Mining District, gave the results of a detailed study of a portion of the slate formation. His most important conclusion in regard to the slate series may be summarized in the following quotations:

"The slates consist of heavy beds of bluish or grayish slates interbedded with which are rhyolite and andesite flows and heavy beds of dacitic tuffs. * * * The tuffs vary greatly, but are usually of medium texture. * * * The coarser phases consist of sharply angular fragments of both rock and feldspar imbedded in a dense, fine-grained groundmass containing more or less clay * * * this rock grades into an exceedingly fine-grained rock felsitic in character and so dense that the microscope does not resolve it. This material has the chemical composition of a rhyolite or a silicified dacite, and is regarded as a fine volcanic ash. * * * The slates differ from the fine, dense tuffs only in the amount of the land waste. By a decrease in the amount of ash and at the same time an increase in the clay, mud, etc., the fine, dense tuff passes gradually into the typical bluish slate. * * * The series as a whole consists of alternating layers or bands of these types of rocks, the bluish slate largely predominating. The rocks as a rule are fairly massive and reasonably fresh, only locally presenting sheared and schistose facies. They all, however, show much silicification and the rhyolite is completely devitrified."

The slate series is considered separated from the igneous rocks to the west by a profound fault. The report includes chapters on the physiography and structure of the region; and the ore deposits are treated in great detail, including a microscopic study of the ores by reflected light.

In September, 1908, the North Carolina Geological and Economic Survey published a geological map of the North Carolina extension of the Virgilina copper district prepared by Laney and Pogue.[2] This is on the scale 1:24000.

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[1]Laney, Francis Baker. The Gold Hill Mining District of North Carolina. A thesis. Yale University, 1908; and published as Bull. 21 N. C. Geol. Survey. 1910.

[2]Laney, F. B., and Pogue, J. E., Jr. An outcrop map of the Virgilina copper district. Scale 1-24000. N. C. Geol. and Economic Survey. 1908.

CHAPTER II.

GENERAL GEOLOGY OR FIELD DESCRIPTION OF THE ROCKS.

INTRODUCTION.

The portion of the Piedmont Plateau described in this report exposes the beveled folds of a great volcano-sedimentary formation. A traverse across the district from northwest to southeast passes over the eroded edges of once horizontal beds, which appear upon the surface as elongated belts and lenses. Their character indicates an origin during a period of great volcanic activity, without parallel except in past geologic ages.

Wide bands of a sedimentary, slate-like rock, composed of varying admixtures of volcanic ash and land waste, have the greatest areal extent. Intercalated with these occur strips and lenses of acid and basic volcanic rocks, represented by fine- and coarse-grained volcanic ejecta and old lava flows. The acid rocks include fine tuffs, coarse tuffs, and breccias, chiefly of a rhyolitic and dacitic character; together with flows of rhyolite and dacite. The basic series embraces fine tuffs, coarse tuffs, breccias, and flows of an andesitic and trachy-andesitic stamp. Gabbro and diabase dikes cut the other formations. (See geological map, Plate IV.)

The region has suffered a period of severe dynamic metamorphism or mashing, consequent upon a great compressive force which squeezed the beds into enormous folds; followed by a time of chemical alteration and mineralization; which in turn was succeeded by a long period of erosion and weathering. The rocks have suffered to a variable degree from all these factors. In general, each formation has a massive and a mashed or schistose phase, with every gradation between the two. The passage of heated solutions has affected all formations, as evidenced by the mineralized zones, the abundance of quartz veins, and the high degree of silicification in many belts of rock, and the universal occurrence of infiltrated iron ores. Finally, erosion has planed off all the upper portion of the folded series; but weathering has proceeded in excess of erosion to such an extent that the region is now deeply decayed, so that only here and there do the rocks project through a thick mantle of decomposed rock or soil.

In spite of the changes undergone, the rocks occur in a number of well-defined, though related and transitional, types, which can be delineated with a fair degree of accuracy on the geologic map. These types will be briefly described, with attention only to those features which may be seen in the field.

SLATE.

The rock included under the term slate forms the greater portion of the area. It occurs in broad bands, with a northeast-southwest trend, separated from each other by belts of volcanic rocks. It shows upon the surface as low, elongated, parallel reefs or ledges, representing in most cases the upturned edges of beds. These are never very abundant nor continuous, because the rock easily weathers to a soil. The outcrops trend in a northeast direction, commonly varying from 40° to 50° northeast; usually dip steeply to the northwest; and they are often badly jointed. Their surface is ordinarily of a grayish, yellowish, or reddish color, due to weathering, and the rock is frequently ready to crumble into a mass of chips and fragments. The slate country is one of subdued relief; in it are never found narrow ridges or steep slopes.

Much of the slate is massive; but in many portions of the district it has been mashed to a greater or less extent, so that it splits easily along certain directions. In its fresh and massive condition, it is a fine-grained, blue, green, gray, or black rock, at times showing well-defined bedding, bespeaking its sedimentary origin. Some of the mashed phases also show bedding planes; these only in part agree in direction with the schistosity.

Broad bands of the slate make up most of the level country on either side of Flat Swamp Mountain. The outcrops may be seen to best advantage along the roads and streams. Perhaps the best developed and freshest outcrops of the slate occur in the bed of Buddle Branch (Plate VI, A), where the bedding and shistosity coincide in having a vertical dip. To the east of Cid the slate is also well developed; here it is greenish, only fairly massive, and bedding planes cut the schistosity at an angle. This is true of the entire northeast edge of the same strip, which extends past Denton and Jackson Hill to the Yadkin. As the river is approached, the formation becomes lighter in color, and a multitude of narrow intercalations of tuffaceous rocks, often represented by single outcrops, are found. The slate area between Fairmont and Flat Swamp Ridge is much more uniform in character. It is massive near the ridge, but becomes schistose as Fairmont is approached, and its outcrops are consequently more badly weathered.

The passage from the slate into adjoining formations is usually not clear cut, but transitional in character. It appears that the slate is intimately related to the tuffs, with which it is associated. Indeed the slate is considered but a fine-grained tuff, with which is mingled a varying amount of the product of land erosion, so that through decrease in amount of land waste, it actually passes into the fine tuff. The transitional character of the slate may be seen as any of the tuff lenses are approached.

ACID FINE TUFF.

The acid fine tuff occurs interbedded with the slate and the acid coarse tuff, and is transitional into each. It has no widespread areal extent, but is abundantly distributed in very narrow lenses, often represented by single outcrops. These are frequently intimately associated with outcrops of the coarse tuff, and the two form tuff bands parallel to the belts of slate. Outcrops may also be found in many portions of the slate country, which are quite similar in size and shape to those of the slate, but differ in being much lighter in color.

The rock varies considerably in appearance from place to place, depending upon its degree of silicification and schistosity. Much of the massive tuff is highly siliceous, varies in color from cream, through gray, to black, and breaks with a conchoidal fracture into chips with keen translucent edges. The outcrops are badly jointed and emit a metallic sound when struck with steel. This type resembles flint or chert, and is called locally "gun-flint." Another phase of the rock is less dense and not so siliceous; it is usually light gray in color, and appears very finely granular. Still another phase is dark green in color, and resembles an arenaceous variation of the slate. Much of the fine tuff has undergone a variable degree of mashing, so that all gradations are found from the light colored, finely granular, massive rock into a sericite schist. It is sometimes difficult to distinguish the mashed fine tuff from the mashed slate; the former, however, is usually lighter in color, and is apt to be more highly colored on weathered surface.

The belt of rock running northward toward Conrad Hill and including the Peters and Silver Hill mines, is made up largely of sericite schists. These are light colored, extremely fissile rocks, breaking into thin sheets which feel smooth and soapy and are quite soft. Upon weathering they take on the most diverse and brilliant colors, especially near mineralized zones. Associated with these occur a number of outcrops which have not been so badly mashed, but that they show their original nature; these are represented by both the fine-grained and the coarse-grained acid tuffs. Since these rocks can form sericite schists through mashing and are actually found in many places grading very gradually into them, it seems evident that this entire belt is made up largely of alternations of the two tuffaceous rocks, which, on account of their nature and favorable position, were involved in extreme mashing.

A lense of fine tuff of different appearance occurs about two miles east of Fairmont. The rock here is a fine-grained, greenish one; slightly schistose and resembling somewhat a sandstone. The outcrops are not abundant. This peculiar variation, which bears a certain analogy both to the slate and to a feldspathic sandstone, is not found elsewhere in the area.

The highly siliceous fine tuff, the so-called gun-flint, occurs in abundant outcrops along the road from Cid to Lexington, and in the neighborhood of Jerusalem Church in particular the roadbed is nearly covered with fragments of this rock. An extremely dense phase of the same rock is found on the dumps at Silver Hill and Silver Valley.

In the slate area which passes between Flat Swamp Mountain and Jacksonhill, many outcrops of the fine tuff may be found in association with the slate. Here it is sometimes massive and sometimes schistose; and more rarely very dense and siliceous. In the belt of coarse acid tuff along the northwest edge of Flat Swamp Ridge are many intercalations of the fine tuff.

ACID COARSE TUFF.

The acid coarse tuff occurs in northeast trending belts, which are separated from each other by bands of slate country. The outcrops are intimately associated with those of the fine tuff, so that the two are mapped together as acid tuff. It is also somewhat extensively distributed as narrow intercalations and lenses within the slate belts.

As with so many of the other rocks of the district, the coarse tuff occurs in all gradations from a massive to a highly schistose condition. Most of the outcrops reveal their fragmental nature upon fresh fracture, but with increasing difficulty in proportion as the rock becomes more severely mashed, so that in some of the sericite schists formed from the coarse tuff, this feature becomes obscured. The outcrops are abundant and prominent; well rounded when massive, and narrow and elongated when schistose. The weathered surface is characteristically bumpy, due to the superior resistance of the fragments, and has a yellowish or grayish color, often the same as that of the lichens which cover it. On fresh fracture, the rock is seen to be composed of a dense, dark colored groundmass, containing broken crystals of feldspar and a variable number of small, angular rock fragments. The fragments are usually one-half inch or less in diameter and represent several kinds of rocks. Most abundant are fragments of a dense, light colored, siliceous rock; but pieces of slate, sometimes showing bedding planes, and of a dark colored, basic rock are not uncommon. (Plate II, A.)

The coarse tuff is prominently developed along the northwestern side of Flat Swamp Ridge. It forms a band between the higher part of the ridge and Flat Swamp Creek, and constitutes a kind of terrace intermediate in elevation. The outcrops vary from massive to somewhat schistose and are extremely abundant—so much so that they interfere with the cultivation of the land. The belt contains many outcrops of the acid fine tuff, and sometimes a transition from this into the coarse tuff may be seen in a single outcrop. The slightly mashed outcrops are elongated at right angles to their schistosity and parallel to the direction of the belt as a whole.

Just east of Kemp Mountain the acid coarse tuff occurs in a badly mashed condition; but still gives abundant proof on fresh fracture and weathered surface of its fragmental nature. The rock here contains a goodly number of dark colored, basic fragments, but not in excess of the lighter, siliceous fragments, so that it may still be considered an acid tuff. The outcrops are extremely narrow and stand up prominently and abundantly. Many are 20 feet long, 10 feet high, and 5 feet thick at the base. (Plate II, B.) These are very striking in appearance, occurring, as it were, in troops. Similar outcrops have been very appropriately compared to military or "cockade hats."

The belt of sericite schists and mashed tuffs, which extends past

A. Outcrop of coarse acid tuff, showing its rough weathered surface, from near Flat Swamp Ridge, Davidson County, N. C.

B. Narrow and elongated outcrops of the mashed acid coarse tuff, east of Kemp Mountain, Davidson County, N. C. Similar outcrops have been described as resembling "cockcade hats."

Silver Hill, has already been discussed. This is regarded as the final result of the mashing of intercalations of the fine and coarse acid tuffs.

The location of a number of other occurrences of the coarse tuff may be seen by reference to the geologic map. Those mentioned, however, are sufficient to indicate its most typical development. The nature of the rock is such that it could have been formed in no other way than as the result of explosive volcanic activity.

ACID VOLCANIC BRECCIA.

The acid volcanic breccia is practically confined to one band, mostly about a half mile in width, which includes Flat Swamp Ridge, and extends in a northernly direction to Cid. Associated with the breccia are found outcrops of the acid tuffs, flows of rhyolite and andesite, and long strips of andesitic tuffs and breccias. (Plate III, A.)

The volcanic breccia is twofold in character, and comprises both a brecciated phase of rhyolite and a very coarse acid tuff with fragments predominant over groundmass and larger in size than one-half inch. The rock is locally called "mountain rock"; its outcrops are large in size and extremely abundant. Enormous boulders up to 20 and 30 feet in diameter are frequent, and, with larger, half buried masses, make up rocky ridges which are almost impassable. (Plate III, B.) Great concentrically weathered plates are at every stage of peeling off. Where most exposed the rock becomes white and pitted upon its surface. Further weathering forms a porous, sponge-like exterior which is characteristic. Where plates have recently peeled off the rock is fairly fresh, light greenish gray in color and spotted with numerous feldspar crystals and light colored, angular rock fragments. In places the phenocrysts and fragments are so arranged as to strongly suggest flow lines. Most of the outcrops are very massive and somewhat jointed. In the vicinity of Cid some have undergone a minor degree of mashing.

When freshly broken, the breccia has a mottled grayish color. A great number of light-colored, angular fragments make up most of the surface. Groundmass and broken phenocrysts fill in between the fragments. Irregular masses of black or dark-green material, present in some phases of the rock, are seen on close inspection to represent basic fragments. These are never very abundant.

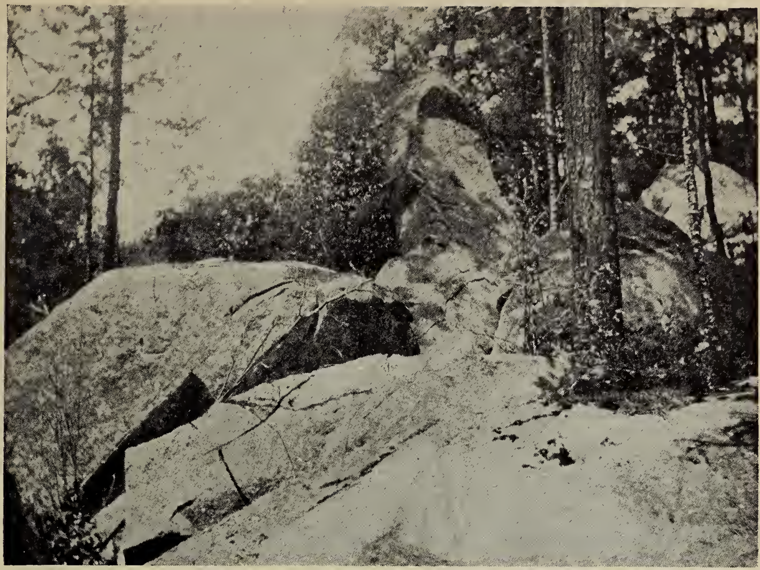
By a gradual decrease in number and size of fragments, the breccia passes imperceptibly into the rhyolite; and in almost any part of the formation isolated outcrops of the rhyolite may occur surrounded by the breccia. Part of the breccia for this reason is considered a brecciated form of rhyolite; that is to say, the viscous rhyolitic magma hardened first upon its surface, and this was broken by the movement of the liquid mass beneath into angular fragments, which became incorporated in the molten paste. Erosion has planed across the mass, exposing part rhyolite and part rhyolitic breccia. All of the rock mapped as acid volcanic breccia, however, is not regarded as having such an origin. Much of the breccia is probably a very course tuff, or ordinary air breccia, with predominant fragments. It is not practical, nor indeed possible, to separate the two phases in the field.

RHYOLITE.

Rhyolite occurs in narrow bands, associated with the acid volcanic breccia, into which it grades. Sharp lines between the two cannot be drawn. It is found best developed along the highest parts of Flat Swamp Ridge.

The rhyolite forms prominent, rounded outcrops, similar to those of the volcanic breccia, but usually not as large. The rock is predominantly massive and is somewhat jointed. Its surface is smooth and of a light gray or white color. In places contorted and wavy lines, indicative of flowage, are visible. The rock is brittle and breaks with a conchoidal fracture into pieces with keen translucent edges. Upon fresh fracture, it appears black, dark green, or grayish green; with feldspar phenocrysts uniformly, though not abundantly distributed. Some phases are exceedingly dense and can be distinguished with difficulty from the highly silicified acid fine tuff.

The rhyolite has its greatest areal extent in an elongated lense occurring on the crest of Flat Swamp Mountain. This represents the exposed portion of an ancient lava flow. Here the rock is massive and surrounded by the volcanic breccia. The rhyolite very gradually passes into a rock containing a few siliceous fragments, and this in turn is transitional into the normal breccia with numerous fragments. Occasional outcrops of the rhyolite may be found wholly enclosed by the breccia. Two other narrow lenses of the rhyolite, forming subordinate ridges, occur a little to the northwest of the main ridge, between it and Flat Swamp Creek. Along



A. Outcrop of the acid volcanic breccia from Flat Swamp Mountain, Davidson County, N. C.

B. Enormous outcrops of the acid volcanic breccia upon Surratt Mountain, Davidson County, N. C

the entire length of Flat Swamp Mountain, from the river to Healing Springs, isolated outcrops of the rhyolite are frequent.

A number of outcrops may also be found upon Grice and Surratt Mountains, but are not extensively developed: the volcanic breccia always surrounds such occurrences. Further to the northwest, in the continuation of the same belt of breccia, after Flat Swamp Ridge has changed into a hilly country, the rhyolite is abundantly developed. Its association with the breccia, however, is still so intimate that in no cases are sufficient outcrops grouped to render it possible to map a small lense of this rock. East of Cid some of the rhyolite has undergone a slight amount of mashing. One occurrence shows a massive core of rhyolite passing on either side into a schist, which somewhat resembles some of the schistose slates. South of the Silver Valley Mine are many outcrops of the rhyolite, but even here the breccia is in predominance.

DACITE.

Dacite is confined to an area of oval outline represented by Kemp Mountain. Its outcrops resemble the outcrops of rhyolite, in that they are abundant, rounded, and light in color. The rock is less siliceous than the rhyolite, and in consequence is more difficult to break with a hammer. On fresh fracture it is grayish-green and phenocrysts of feldspar and small, dark green patches of chlorite and biotite are discernible. Some of the feldspars are slightly greenish.

Kemp Mountain rises abruptly from Lick Creek which flows along its eastern border, and appears from this point of view to be a narrow ridge. Its slopes, however, are more gentle in all other directions. This occurence probably represents the remnant of an old lava flow, of slightly more basic nature than the flows of rhyolite. Its rounded contour on the map is due to the fact that the observer is not looking down upon the upturned edge of the flow, but more nearly upon its horizotal surface. Since there is no direct evidence of flow structure, it is possible that the mass may represent an old volcanic neck or conduit, or perhaps an intrusion which never reached the original surface. The first explanation is simpler, more in accord with structure, and is consequently preferable.

ANDESITIC FINE TUFF.

The andesitic fine tuff is a fine-grained phase of the andesitic coarse tuff and breccia, and represents consolidated dust and ashes from explosive eruptions of more basic character than those which gave rise to the acid series of rocks. Fragments are almost entirely wanting and are never visible to the naked eye. Upon addition of these, the rock passes into the andesitic coarse tuff and breccia. In no place is its areal distribution of sufficient extent to show upon the geologic map. Its separate description is warranted from its analogy to the acid fine tuff.

The rock is dense and somewhat less siliceous than its acid analogue. In color it is either greenish or green mottled with purple. Outcrops are small, somewhat rounded, of a grayish-green exterior, and rough to the touch.

ANDESITIC COARSE TUFF AND BRECCIA.

The andesitic coarse tuff, composed of groundmass, phenocrysts, and a subordinate number of fragments, and the andesitic breccia, with predominant and larger fragments, are included under one head. Their intimate association makes it impossible to separate the two in the field. No evidence is found that part of the andesitic breccia is a flow breccia.

The andesitic tuff and breccia forms long, narrow strips and broader lenses of important areal extent; alternating with the areas of the slate and the acid series of volcanic rocks. It ranges all the way from a very massive variety, made up almost wholly of green fragments, to a greenstone schist, which in itself contains little evidence of its fragmental nature. The outcrops are abundant and prominent (Plate V, A): when massive, they are low and well rounded; with increasing degree of schistosity, they become elongated and narrow, like inverted wedges, and resemble much in shape the "cockade hat" outcrops of the mashed acid coarse tuff. Only a few occurrences fail to have a bumpy weathered surface, which reveals the fragmental nature of the rock even when this feature is not observed on fresh fracture.

The massive rock is heavy, tough, dark-green, and composed almost entirely of green fragments up to ¾ inch and larger in diameter. Dark green material, containing feldspar phenocrysts, fills the space between the fragments. Numerous particles of pyrrhotite are often present. More schistose varieties appear less fragmental; because fragments are converted into secondary minerals. Often the mashed rock is somewhat lighter in color than the massive variety.

Just west from Bald Mountain occurs an area of rather massive coarse tuff and breccia. Outcrops are abundant, but not large, and contain considerable pyrrhotite. The soil is a brilliant red and sticky; its color is doubtless due to the oxidation of the pyrrhotite. The formation here seems little mineralized, except by iron ore. A lens of the same rock occurs southeast of Denton. Here it is not as massive. The rock is again seen, and in a massive condition, about a mile east of Kemp Mountain.

A long narrow intercalation of the same rock is found along the northwest edge of Flat Swamp Ridge, separating the acid coarse tuff and the acid volcanic breccia. This extends from near the Yadkin River to within two miles of Cid; the outcrops have undergone a variable degree of mashing, and range from massive to fairly schistose. Beginning a half mile east of Snyder's Mill, a parallel band extends practically to Cid. Within this band are found specimens which contain large fragmental inclusions of an acid rock. Immediately west of the Silver Valley Mine is found a small lens of the schistose basic breccia.

The andesitic tuff and breccia has its greatest areal extent in a lens beginning northeast of the Silver Hill Mine and extending to Three Hat Mountain. (Plate V, A and B.) Here the rock varies considerably; but all occurrences are more or less schistose. Outcrops are abundant and large, and mostly elongated. The resulting topography is rugged. (Plate V, B.) Flows of andesite are associated with the fragmental rock.

Southwest of Silver Hill occurs a small area of the breccia, which has been mashed into resemblance to the slate in which it occurs. The difference is brought out on the weathered surface. A short distance to the east occurs a larger area intercalated with a lense of acid tuff. Numerous other smaller occurrences of the fragmental andesite are found throughout the district.

The wide distribution of the type of rock described suggests the great complexity of the volcanic period, during which it was formed. There were undoubtedly many alterations between outbreaks of acid and comparatively basic magmas.

ANDESITE.

Andesite is of very limited occurrence within the district. It forms several narrow strips and lenses of small areal extent, which represent the remnants of old flows. The rock is massive, somewhat jointed, and mostly porphyritic; that is, it contains recognizable crystals of feldspar in a fine-grained matrix. In one place the rock is amygdaloidal, and is filled with small, round and oval areas of greenish material, representing the vesicles of a surface lava subsequently filled with infiltrated material. The outcrops are not large, but are fairly abundant, and are usually rounded.

The massive andesite is a fine-grained rock, varying in color from greenish-gray, through epidote green, to dark bluish-purple, in which small specks of epidote and crystals of feldspar may be usually recognized. The rock is tough and heavy. The amygdaloidal phase is unmistakable; for its distinctive texture and honeycombed appearance on weathered surface are features possessed by no other rock in the district.

A strip of the andesite about 100 yards wide and over a mile long crosses the Fairmont-Denton road southeast of Grice Mountain. The rock is dark blue on fresh break; its weathered surface is a dull gray and rough like coarse sandpaper. Upon either side, standing up in fairly prominent, well-rounded ridges, occurs the acid volcanic breccia. This occurrence of andesite represents the upturned edge of a flow.

The amygdaloidal andesite is found on the southwest end of Three Hat Mountain. A mile and a half southwest of this occurrence, a dense phase of more alkalic nature forms a small eminence. This might more properly be called a trachy-andesite. A half mile east of Kemp Mountain also occurs a trachytic phase of the andesite. This phase in hand specimen resembles the dacite of Kemp Mountain. In position it is closely associated with a lense of massive andesitic breccia. Other occurrences within the district are of limited extent.

DIKE ROCKS.

GABBRO.

Gabbro occurs widely and abundantly distributed throughout the district in the form of dikes. It shows upon the surface as rounded, yellowish boulders, locally called "nigger-heads," ranging in size up

A. Wedge-shaped outcrops of the mashed andesite breccia a mile west of three Hat Mountain, Davidson County, N. C.

B. Weathered surface of the andesitic breccia, showing the characteristic billowy or bumpy exterior. Three Hat Mountain, Davidson County, N. C.

to 9 or 10 feet in diameter, and distributed in lines following the trend of the dikes. The largest dikes are usually more or less prominent topographic features in the shape of low, well-rounded ridges or mounds. (Pl. XII, B.) This, together with the abundance of boulders, renders their tracing a matter of little difficulty. From an eighth of a mile in width and three or four miles in length, the dikes range down in size to those which are exposed upon the surface by the presence of only a few boulders. The dikes are most abundantly developed in the vicinity of Fairmont, on either side of Flat Swamp Mountain, near Lick Creek Church, north of Denton, and a mile southwest of Silver Valley. A traverse from any point across the district, along a line at right angles to the trend of the formations, would hardly fail to cross a number of gabbro dikes of various dimensions.

The trend of the dikes in all cases coincides with the schistosity of the formations in which they occur. Moreover, the large majority of the dikes are found in the slate or acid tuff; while the more massive formations, such as acid and basic flows and breccias, are comparatively free from them. The schistosity is therefore considered to have been developed prior to the introduction of the dikes, and to have been, as an easy line of yielding, a controlling factor in their introduction. An apparent exception occurs about a mile southwest of Silver Valley mine, where a large dike, after following the schistosity for a mile and a half, branches to the left at an angle of 60°, and continues an equal distance in a northerly direction. In making this bend, it passes from a fairly schistose part of a formation into a rather massive phase. Jointing was probably in this case the dominant factor in controlling the introduction of the molten gabbro; yet the schistosity controlled as long as it was present.

A particular dike will be found to vary in width from place to place, and in general will tend to pinch out at either end. The contacts between the dikes and adjacent formations are much obscured by weathering; so that it is impossible to discern any contact effects. The deeply weathered nature of the contacts, however, bespeaks a zone susceptible to alteration and doubtless rendered so by contact action. Jointing is well developed, and of such a nature as to indicate the operation of a force after the introduction of the dikes.

The gabbro is a greenish-gray rock, of medium grain and homogeneous texture, in which crystals of green hornblende and areas of opaque feldspar may be recognized. It is tough and heavy and very susceptible to weathering. In point of age, it is considered the second youngest rock in the district, since it cuts the other formations, and is itself cut by dikes of diabase.

DIABASE.

Diabase occurs widely, though not abundantly, scattered throughout the district in the form of dikes, which show upon the surface as narrow lines of rounded, yellowish boulders, locally called "nigger heads." These dikes prefer no particular formation, but are found universally distributed, cutting the other formations. They vary in size from a few feet in width and a few yards in length, to the largest, about a hundred feet in width and slightly over a mile in length. The majority conform to the former, rather than to the latter, dimensions. In trend they also vary, but the more common directions are included between N. 30° E. and N. 30° W. The trend of the dikes coincides with important joint directions.

In two localities the diabase dikes are found cutting the gabbro: one about a half mile southeast of Fairmont; and the other at a point one-half mile southeast of Flat Swamp Mountain and one-half mile southwest of the Healing Springs-Jacksonhill road. The diabase is therefore younger than the gabbro, and its introduction seems at least in part conditioned by a set of joint planes, which are also younger than the gabbro, since they involve it. It is possible that original jointing may have controlled the introduction of many, or even all, of the dikes.

The diabase is a massive, fine-grained, dark blue rock; very tough and with a waxy luster on fresh fracture. Upon examination it is seen to be a closely knit aggregate of dark colored minerals, among which striated feldspar may be recognized with the hand lens. Although the rock is high in olivine, this constituent can not be recognized. The diabase is doubtless of Triassic age, because a dike rock of similar character occurs in an adjoining Triassic belt about 50 miles to the east, and in places is found cutting both the slates and sandstone. This conclusion is borne out by the unusual freshness of the diabase, which suggests a rock of post-Paleozoic age and one that has not suffered from dynamic metamorphism.

CHAPTER III.

A DETAILED DESCRIPTION OF THE ROCKS.

INTRODUCTION.

The area described in this report is composed of a number of rock types, distinctive in character, but intimately related in mode of origin. The surface bevels the upturned edges of once horizontal beds of slate, with their abundant intercalations of acid and basic tuffs, breccias, and flows. The region beyond doubt is indicative of ancient volcanic activity on a large scale.

The slate is not a normal product of land erosion, but bears evidence of a peculiar origin by a liberal admixture of fine-grained volcanic ejectamenta. With decreasing amounts of land waste, and increasing proportions of ash, this rock grades into a fine-grained tuff of acid nature. This, in turn, with increased size of material, passes into an acid coarse tuff, composed of ash, lapilli, broken crystals, and rock fragments. Closely related is an acid volcanic breccia, made up largely of angular rock fragments and grading into acid flow rocks. The latter are of two kinds, rhyolitic and dacitic, and represent ancient lava flows. Intimately associated with the slate and acid rocks, and alternating with them, occurs a series of basic fragmental rocks and flows. These are of an andesitic nature and comprise fine tuffs, coarse tuffs, breccias, and old lava flows of both porphyritic and amygdaloidal habits.

This entire series, built up as a unit during a long period of time, has been folded, mashed, and altered. The degree of metamorphism has varied from place to place, so that each type of rock has a two-fold character; comprising a badly altered or schistose phase, and a less badly altered or massive phase. A study of the badly altered types, in which the character of the original rock is masked by subsequent changes, will yield little as to their true nature. It is only by first considering the massive, relatively unchanged rocks, and afterwards proceeding to their more altered derivatives, that the original nature of each phase can be ascertained. This, then, is the mode of procedure adopted in the following descriptions.

Each rock type will be classified according to the characters exhibited by its massive occurrences. Otherwise, quite diverse rocks, which had undergone the same degree of metamorphism, would fall together. (See geological map, Pl. IV.)

SLATE.

The sedimentary rock, composed of varying admixtures of land waste and volcanic ash, is comprised under the term slate. This rock has the most widespread occurrence of any type of rock within the district. It underlies, and has given rise to, the greater portion of the area of gentle slopes. It appears in small outcrops or reefs, standing on edge and mostly badly weathered, occurring at short intervals along the roads and streams.

Macroscopic description.—A wide range of appearances is presented by the slate. When fresh it is dark green, dark to light blue, or grayish-black to black. With increasing proportions of ash, these colors grade into lighter shades, and finally into light grays and whites. Upon weathering, the colors brighten and become quite diverse, and sometimes even brilliant. Shades of purple, blue, green, red, yellow, and gray in endless variations may appear. In texture the slate is dense, so that little can be discerned with the naked eye. In certain specimens small specks of biotite may be plainly recognized. In many occurrences bedding planes are visible (Pl. VI, B); and often a certain degree of schistosity has been developed. Sometimes the bedding and schistosity coincide; more often they do not. There are phases of the slate which have been changed into sericite schists. These probably contain much tuffaceous material.

Microscopic description.—The slate is so fine-grained that the microscope reveals only indifferently its mineralogical content. The highest power shows a dense, crypto-crystalline groundmass of a grayish to a greenish color, made up of an aggregate of quartz and feldspar, difficultly distinguishable and knit together by numerous sericite fibers. Often material of a higher index of refraction is intermingled, which consists mostly of grains of epidote and clinozoisite, with occasional small patches of chlorite. Variable but small amounts of kaolin and organic matter may be present. Often shreds and patches of a greenish, pleochroic biotite, of very ragged outline and porous, sponge-like interior, are uniformly distributed. Frequently associated with them are ragged, porous masses of black material, perhaps partly iron ore and partly organic matter.

A. Typical outcrop of slate in Buddle Branch, southeast of Silver Hill, Davidson County, N. C.

B. Hand specimen of a black slate with cross bedding strikingly brought out on the weathered surface.

TEXTURE.

Bedding and the arrangement of the secondary minerals are the chief textural features. The bedding visible in hand specimen is shown by the low power to be due to a uniform variation in size of grain along certain lines. In the great majority of cases this was undoubtedly caused by changed conditions of sedimentation whereby coarser or finer material was deposited. In some instances, especially in those where the rock has had some degree of schistosity coinciding with the bedding planes imposed upon it, one must recognize that solutions, rising along certain lines, may have produced a re-crystallization and a consequent banding. In one outcrop of slate may be seen the interesting occurrence of cross-bedding, strikingly brought out on the weathered surface and easily visible under the microscope. The secondary minerals are due both to dynamic and chemical metamorphism. The biotites and sericite are the result chiefly of the former. The biotite has no particular arrangement; the sericite has a tendency to align itself at right angles to the force inducing schistosity. Both minerals increase in amount with the degree of mashing.

CHEMICAL COMPOSITION.

A determination of the alkalies in a typical black slate is given in the following table. Two analyses of slates from the Gold Hill region, and two of "slate" from the Haile Mine of South Carolina within the same belt of rock, are included for comparison.

ANALYSES OF SLATE.*

	I	II	III	IV	V
SiO_2		52.62	62.46	61.02	44.61
Al_2O_3		33.20	16.10	25.54	31.57
Fe_2O_3		4.04	1.17	4.04 (with FeO)	3.55 (with FeO)
FeO			5.49		
MgO		0.27	2.27	0.14	0.22
CaO		2.52	0.36	0.60	0.20
Na_2O	1.61	3.80	2.16	2.19	6.96
K_2O	2.07	0.49	2.85	1.81	6.97
H_2O-			0.53	4.20 (with H_2O+)	5.80 (with H_2O+)
H_2O+			2.53		
CO_2		0.66			
S			0.26		
Total		97.67	96.17	99.96	99.88

For further comparison an average was made of the percentage of alkalies found in the 33 slates which were analyzed in the chemi-

*

I. Partial analysis of Black Slate, ½ mile south of Silver Hill. A. S. Wheeler, Analyst.
II. Analysis of typical Black Slate, Gold Hill, N. C. R. T. Allen, Analyst. Laney: Gold Hill Mining District: 41.
III. Analysis of typical Banded Blue Slate, Gold Hill, N. C. A. S. Wheeler, Analyst. Ibid.: 41.
IV. and V. Analysis of "Slate" from the Haile Mine, S. C. Chas. Baskerville, Analyst. Nitze & Hanna: Gold Deposits of North Carolina: 34.

cal laboratory of the United States Geological Survey from 1880 to 1903.[1] These include normal slates from Vermont, New York, Pennsylvania, Michigan, Wisconsin, and Minnesota. The result is as follows:

Average Na_2O	0.89%
Average K_2O	3.68%

The proportion of soda to potash is 1:4.1. In only two of the thirty-three slates was the percentage of soda greater than one-half the percentage of potash. These figures show that the normal slate, during an ordinary cycle of land erosion, loses soda much more readily than potash; so that the final result is a preponderance of potash over soda, irrespective of the original proportions. When the reverse is found to be the case, special conditions must be sought to explain this unnatural relation.

In the slates of the Carolina Slate Belt, it is seen from the analyses given that the soda is about equal to, or in greater amount than, the potash. According to the quantitative nomenclature, the Carolina slate is sodipotassic to dosodic; whereas a normal slate is dopotassic. This feature indicates that the rock has not undergone a normal cycle of erosion, for such would have brought it in line with the average slate. On the contrary, it suggests that the original material of the rock was transported only a short distance, and, further, that the material was presented to the transporting agent in a condition of mechanical disintegration. A long transport of finely comminuted material would have resulted in the deposition of sediments low in soda. A long period of chemical weathering, previous to transportation, would have had the same effect. The conclusion, which is strengthened by the geologic occurrence and relation to the tuff deposits, is: that the slates were derived chiefly from great masses of volcanic ejecta, and deposited by water, with varying amounts of land waste, at no great distance from the source of the material.

Classification.—It is realized that the type of rock just described does not, in all its phases, correspond to a true slate.[2] Yet the term slate is applied, and for two reasons: First, the rock is an admixture of land waste with variable amounts of tuffaceous material, which has

[1]Clarke, F. W. Analyses of Rocks. U. S. Geol. Survey, Bull. 228 (1904): 337, 338, 339, 340, 341, 342, 344, 345, 346.

[2]"Slates are dense, homogeneous rocks * * * characterized by a remarkable cleavage, by means of which they split into broad, thin sheets * * * The slates represent * * * the finest material of land waste by erosion * * * With such material more or less volcanic dust and debris tuffs may be mingled." Pirsson, L. V. Rocks and Rock Minerals: 369.

become indurated and had a certain degree of slaty cleavage imposed upon it. Second, many specimens so strongly resemble in appearance a normal slate that any other term would be misleading.

WEATHERING.

The weathered slates present a wide diversity in appearance, depending upon differences in composition and degree of metamorphism. There is a varying balance between the forces of mechanical and chemical disintegration. A massive, badly-jointed slate suffers much from the former; a severely mashed or schistose phase yields readily to the attacks of the latter. Slight variations in composition introduce further complications. The result, therefore, is that no two outcrops are exactly alike, and one is apt to consider the formation more complex than it is, forgetting that the forces of weathering concentrate upon and accentuate original differences, however slight.

Joint planes and cleavage cracks afford easy access to solutions. The first effect of weathering is a yellowish staining along these lines and upon the surface. This proceeds inward until the entire exposed portion of the outcrop becomes a shade of yellow. Often a block of slate will show a line of demarcation between the weathered exterior and the unweathered core. The greater the amount of schistosity, the more uniformly and rapidly does the weathering proceed, with the development frequently of quite vivid colors. The rock finally crumbles into small chips and fragments of dull yellow tones. The resulting soil is filled with these chips, so that its nature is often apparent at a glance. In color it is largely the same as the fragments, grayish or yellow, although the presence of pyrite in the rock may give rise to a red color over considerable areas. With increased amount of ash in the original rock, the soil becomes light gray in color.

THE ACID FINE-GRAINED TUFFS.

The acid fine-grained tuffs occur interbedded with the slates and coarser tuffs. They have no extended areal distribution, but may be found in nearly all parts of the district in outcrops of limited size. On the one hand, they grade very gradually into the slates; while on the other, they pass into the acid coarse tuffs. At times there are frequent alternations between the three in the course of a few yards, bespeaking a rapid change of conditions during their deposition.

Macroscopic description.—The fine-grained tuffs are extremely dense, hard rocks, usually light in color; though, through small admixtures of organic matter, they may become dark colored or black. They have been silicified and consequently are very brittle, breaking with a conchoidal fracture into small, translucent chips and slivers of a very keen edge. They emit a clear, ringing sound when struck with the hammer. A light gray or cream color is the most common, though various shades of greenish-gray, and even dark gray or black, are not uncommon. Many specimens have a greasy, oily appearance upon fresh fracture. The harder, denser varieties of these rocks are locally called "gun-flints," and have been described as "whetstone slates" and "hornstones." These resemble very much a chert or novaculite. The texture varies from fine graular to dense, but even in the coarser facies, little or nothing can be told of the mineralogical content. Bedding planes are sometimes visible; otherwise the rock is quite homogeneous. The greater number of outcrops have suffered little from mashing; although some of the sericite schists, particularly in the vicinity of Silver Hill, show by their occasional gradation into the massive tuffs to have been derived from them.

Microscopic description.—The microscope reveals a dense, cryptocrystalline groundmass, in which may be seen fragmentary crystals of quarts and feldspar, very rarely a fragment of another rock, and a host of other minerals, mostly secondary, in subordinate amounts.

The quartz occurs in small fragmental crystals. It rarely shows good crystal outline: in such cases it has been recrystallized. Occasional particles have a moon-shaped contour, representing the intervening cell walls of a highly expanded pumice.

The feldspar is both orthoclase and acid plagioclase, and is also fragmental in outline. It is usually clouded with kaolin, often to the extent of obscuring its nature. In amount it is subordinate to the quartz. Microline could be distinguished in one instance.

Iron ore occurs in small grains, and at times in larger aggregates, from which a portion has been removed by solution. It is largely pyrite, of later age than the rock.

Colorless garnets occur very rarely.

Fragments are quite rare. In one or two instances small pieces of a rock composed of plagioclase laths were recognizable.

The groundmass consists of a fine-grained mosaic of quartz and feldspar fragments, often knit together by sericite fibers. Present also are varying amounts of epidote and clinozoisite grains, patches of chlorite, calcite, kaolin, and rarely organic matter.

TEXTURE.

Many of the fine tuffs under the microscope show no special textural features. Where bedding planes are visible, they are due to a variation in size of material. An interesting feature in one slide is a normal fault in a bedding plane, with a throw of one-eighth inch. The resulting fissure is filled with epidote, quartz and calcite. Where the secondary minerals are abundant, there is a tendency for these to bend and wrap around the phenocrysts. If much sericite be developed, this material is apt to be arranged in definite lines.

CHEMICAL COMPOSITION.

A determination of the alkalies in one of the densest of the tuffs, which strongly resembled a chert, was made, with the following result:[1] Na_2O . . . . . . 0.22; K_2O . . . . . . 3.54.

The rock evidently has a fair feldspathic content. A complete analysis was not made, on account of the large amount of infiltrated silica.

Classifiation.—The microscopic description and field relations of the rock indicate that it is a fine-grained tuff, of a rhyolitic or dacitic character. It is considered to be a volcanic ash, in part deposited by water as indicated by the bedding planes, which has been indurated, highly silicified, and metamorphosed.

Arenaceous phase.—Occurring one and one-half miles east of Fairmont is a small area of a fine-grained, grayish-green, schistose rock, of an arenaceous nature. The rock is coarser than the ordinary fine tuff, so that its granular character can be seen with the eye. The microscope shows this rock to be a slightly coarser phase of the tuff, in which there is a good proportion of fair-sized quartz grains, some slightly rounded and others of a decidedly sherd-like outline.

WEATHERING.

The acid fine tuff, like the slate, has a varied mode of weathering, according to its degree of schistosity. The massive varieties, by virtue of their numerous joint planes, are easily attacked by solu-

[1]Partial analysis of acid fine tuff ("gun-flint"), from Silver Hill, Davidson County, N. C. A. S. Wheeler, Analyst.

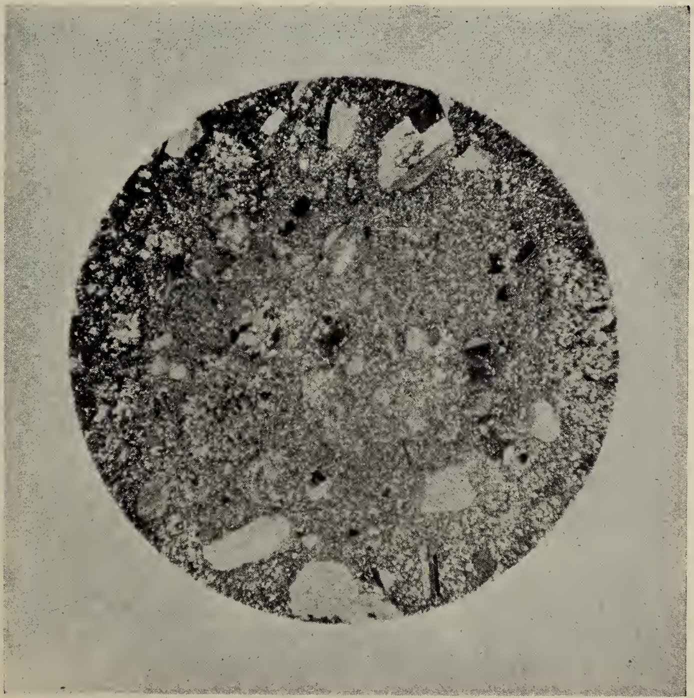
tions. As a result, the outcrops and loose blocks are covered to a depth up to $1/8$ inch with a crust of yellow clay-like material, which mashes beneath the blow of a hammer. Small fragments and blocks become easily detached from the outcrops, and are so abundant where bands of the fine tuff cross the roads, that one on horseback could recognize the formation in the dark, by the ringing sound caused at each step by the iron horse-shoe striking the fragments. The resulting soil is yellowish to grayish, and reveals its nature by the numerous chips of the parent rock which lie upon the surface. The schistose phases weather in a somewhat different manner, in that they tend to decay in place until they finally crumble into an ash-like material, perhaps quite similar in appearance to the original volcanic ash and dust which compose them. During this process the outcrops are often highly and beautifully colored, due to the degree of oxidation of the iron. This is especially true in places where there has been mineralization, so that the brilliant colors are often, and justly, taken as a guide in prospecting.

THE ACID COARSE TUFFS.

The acid coarse tuff has a widespread areal extent, second only to the slate. It forms bands of varying width, usually a mile or so, trending in a northeast and southwest direction. It also has a frequent occurrence within the belts of slate, where it is found in narrow, restricted beds, often represented by a single outcrop. Its best development is just west of Flat Swamp Ridge, and in a badly mashed strip extending from Silver Hill to Conrad Hill.

Macroscopic description.—The coarse tuff differs from the fine tuff in that its fragmental nature can always be recognized in a hand specimen. It is greenish-gray to bluish-gray in color; its weathered surface is a kind of yellowish or neutral gray. This rock resists weathering much better than does the slate, so that its outcrops are always prominent. Upon close examination it is seen to be composed of a bluish or greenish matrix, whose nature can not be made out, in which are imbedded numerous easily recognizable feldspar phenocrysts. (Plate VII, A.) A diligent search always reveals a greater or less number of included rock fragments. These are frequently quite prominent, though rarely predominant. Sometimes the rock seems to be made up entirely of groundmass and phenocrysts. The fragments vary in size up to $1/2$ inch in diameter;

A. HAND SPECIMEN OF THE ACID COARSE TUFF. FRAGMENTS ARE SMALL AND SUBORDINATE TO THE DENSE GROUNDMASS.



B. PHOTOMICROGRAPH OF AN ACID TUFF, DAVIDSON COUNTY, N. C. 30 DIAMETERS; POLARIZED LIGHT; SHOWING THE FRAGMENTARY CHARACTER OF THE ROCK.

where they are predominantly larger the rock is called a volcanic breccia. The most abundant fragments are light colored, siliceous ones; though fragments of slate and of a dark colored, basic rock may be occasionally seen. The rock is fairly brittle, but varies in this respect, depending upon the amount of silicification. Large areas of the coarse tuff are massive, while considerable extents of them have suffered different degrees of mashing. As a final result of metamorphism, they pass into sericite schists.

Microscopic description.—Fifteen thin sections of specimens from all parts of the area proved the coarse tuff to be fairly uniform in character. All agree in showing fragmental phenocrysts of quartz, orthoclase, and acid plagioclase, together with fragments of one or more kinds, imbedded in a fine-grained matrix. (Plate VII, B.)

Orthoclase is the most abundant phenocryst and occurs in subhedral to anhedral and fragmental crystals, usually of a brick-like or slightly elongated outline. The edges in many instances are somewhat rounded. Carlsbad twins are often seen. Occasional epidote and clinozoisite grains, rare prisms of apatite, and sericite fibers in cases where mashing has been effective, occur as inclusions. The alteration is to kaolin, which always gives to the mineral a dusty or cloudy appearance. The "basket" twinning characteristic of microcline sometimes occurs, and this seems to have been formed from the orthoclase by mashing, as only the schistose phases of the rock have this feature; and there is often a gradation from the microcline into the unchanged orthoclase.

Plagioclase, as a phenocryst, is subordinate in amount to orthoclase. It occurs in subangular, lath-shaped forms, whose extinction angles show it to be at the acid end of the series, hardly more basic than oligoclase.

Quartz is usually in smaller amounts than the feldspars, and occurs in grains and aggregates of grains. It ordinarily has a fragmental outline, though it sometimes shows a fair hexagonal form, due to recrystallization. There are certain areas which have the appearance of shattered and recrystallized phenocrysts. Occasional undulatory extinctions may be seen. A few small anhedrons show embayments filled with groundmass.

Biotite is frequently present in the form of shreds and sponge-like crystals of ragged outline. These show various degrees of alteration into a pale green chlorite.

Iron ore occurs as small specks and grains. It is probably mostly pyrite. Associated patches of chlorite are sometimes seen.

Fragments occur in all the sections, and in practically all cases are less abundant than the groundmass. They are angular in outline and consist of several kinds of rock. Most abundant are fragments of the acid fine tuff and slate; although there are often present fragments of a rock andesitic in nature. The latter type, under crossed nicols, shows itself to be composed of a mesh of striated plagioclase laths of a medium acid nature, mixed with such secondary minerals as biotite, sericite, epidote and clinozoisite. Sometimes larger, striated feldspars occur as phenocrysts. With increasing number of andesitic fragments, the rock passes into an andesitic coarse tuff or breccia. There are probably also fragments of rhyolite present, but these can not be distinguished with certainty from the fine tuff. A type of fragment seen in one slide deserves special mention. It is composed of sponge-like biotite crystals and rounded areas of chalcedonic silica, shot full of slim, colorless needles of actinolite: it probably represents an amygdaloidal andesite.

The groundmass consists of a dense mosaic of quartz and feldspar, with varying amounts of sericite, epidote, and clinozoisite. More or less of a finely granular, grayish-green, non-polarizing material, most probably kaolin or clay, is frequently associated. (Plate VII, B.) The common type of groundmass has a brownish-gray, clay-like appearance in plane light, and becomes almost dark between crossed nicols.

TEXTURE.

The absolute lack of order and regularity with which the components are thrown together is the most striking textural feature. In one slide a faint suggestion of bedding was noticed. Rather interesting is the fact that in some cases where the hand specimen shows a certain amount of schistosity, the microscope fails to reveal any mashing effects.

Classification.—The microscopic details and field relations are considered sufficient to classify the rock as an acid coarse tuff. Its mode of origin and somewhat variable nature does not permit of such an accurate classification as would be possible with a rock which had solidified from a molten magma. It is largely, however, rhyolitic to dacitic in character and in rare cases it strongly suggests a trachytic character. It doubtless represents the explosive phases of the rhyolitic and dacitic flows exposed within the district. The term, therefore, will embrace all gradations between a trachytic and dacitic tuff: a finer distinction is impossible.

WEATHERING.

The mode of weathering of the acid coarse tuff depends largely upon the degree of mashing it has undergone. The massive varieties have the more distinctive mode of yielding to the attacks of the elements. The groundmass is less resistant than the fragments, and the result is that a bumpy surface is developed, caused by the fragments standing out from the matrix. This is so characteristic that it is possible to recognize the fragmental nature of the coarse tuff at a glance. The outcrops are large and prominent and are colored a dull yellow or neutral gray on the surface. (See Plate II, A.) The weathering is more mechanical than chemical, and the resulting soil is a grayish one, with no especially distinctive characteristics. The more schistose phases tend to become chemically altered, rather than mechanically disintegrated; so that the badly mashed facies are highly colored, and indeed in many cases are indistinguishable from the sericite schists resulting from the metamorphism of the fine tuffs. The mashed fragments tend to become ash-like and white: thus the fragmental nature of some of the mashed tuffs, not noticeable on fresh break, is brought out by weathering.

THE ACID VOLCANIC BRECCIA.

The acid volcanic breccia is a composite type based more upon macroscopic and field distinctions than upon microscopic differences. It includes two phases, alike mineralogically, but unlike in mode of origin; and grading the one into the other in such a manner that no lines can be drawn upon the geologic map separating the two. On the one hand, the coarse tuff containing fragments predominant over groundmass and larger than ½ inch in diameter is called a volcanic breccia; on the other, the brecciated form of rhyolite, which imperceptibly grades from a massive flow rock into a cemented mass of rhyolite fragments, and which is considered a rhyolite broken into angular fragments through flowage, is given the same name. The greater portion of the rock is characterized by the fragments predominating over phenocrysts and groundmass. While no hard and fast lines can be drawn between the rhyolite or acid coarse tuff and the volcanic breccia, its delineation may be indicated with sufficient accuracy to warrant its separation. It is characteristically developed along Flat Swamp Ridge, forming the main portion of this elevation.

Macroscopic description.—The breccia, when typically developed, is easy to recognize. It is made up largely of light colored fragments, usually ½ to 1 inch in diameter; though some were noted 2 feet long. (Plate VIII, A.) A closer examination reveals these to be light greenish-gray to white in color, quite siliceous, and to contain an occasional feldspar phenocryst. There may also at times be seen fragments of other rocks, chief among which are small, irregular pieces of a dark, basic rock, composed of numerous biotite specks surrounding minute feldspar crystals. The groundmass is usually dark green or gray, and in it are found abundant small feldspar phenocrysts. The breccia forms enormous rounded outcrops literally covering the ridges which they form. (See Plate III, A and B.) It grades into the rhyolite by containing smaller and fewer fragments, until the two become indistinguishable. At times the brecciated character can only be seen on the weathered surface. A type composed largely of fragments may show flow lines.

Microscopic description.—The volcanic breccia under the microscope differs so slightly from the coarse tuff that a detailed description will not be given. Phenocrysts of orthoclase, plagioclase, and quartz are as described under the previous rock. The groundmass differs little, if any, and the same secondary minerals are present.

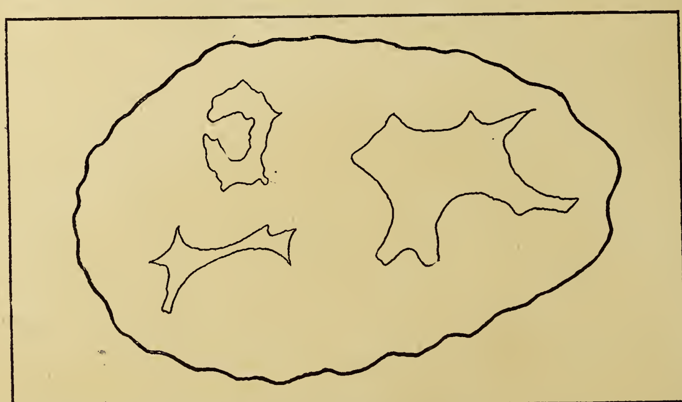


FIG. 2—SKETCH OF SMALL GLASS SHERDS WITHIN A FRAGMENT OF THE VOLCANIC BRECCIA. MAGNIFIED ABOUT 88 DIAMETERS.

In the breccia, however, a much greater amount of green biotite is developed, and the fragments are much more abundant. Fragments

A. HAND SPECIMEN OF THE ACID VOLCANIC BRECCIA FROM FLAT SWAMP RIDGE. IT IS MADE UP OF PREDOMINATING LIGHT COLORED ACID FRAGMENTS OVER ONE HALF INCH IN DIAMETER. A DARK COLORED ANDESITIC FRAGMENT MAY BE SEEN IN THE CENTER OF THE SPECIMEN.

B. SMALL BOULDER OF THE ACID VOLCANIC BRECCIA, SHOWING A CHARACTERISTIC SPONGELIKE SURFACE DEVELOPED IN WEATHERING.

of the acid flows and tuffs are the most frequent. Occasional andesitic fragments may be seen, composed largely of biotite and plagioclase. One fragment of acid nature is deserving of special note, for it contains fragments in the shape of shreds, that are so characteristic of explosive volcanic activity. (See figure 2.) This suggests the complexity of the volcanic activity, for here is evidence in one place of at least two outbreaks, with a long interval between. Flow lines are better seen in hand specimen than under the microscope. (See Plate IX, A and B.)

Classification.—This rock from its field relations and microscopic make-up is considered to be largely rhyolitic in character; though becoming dacitic at times, and perhaps in rare instances trachytic. It is therefore called an acid volcanic breccia: this term is understood to include both coarse volcanic ejecta and the brecciated phase of rhyolitic lava flows.

WEATHERING.

The volcanic breccia is but little jointed and quite massive, and resists weathering more readily than any other rock in the district, except perhaps the rhyolite. Consequently it forms prominent ridges and is found in enormous outcrops. These weather to a fairly smooth surface, with great concentric shells or plates at every stage of peeling off, many being ready to fall at the touch of the pick. In color these masses are a light gray, or particularly in the loose fragments, a dull dirty gray. The surface is at first fairly smooth, or only slightly pitted; but the pieces which fall down soon become quite rough and present a surface very much like that of a sponge. (Plate VIII, B.) This sponge-like weathering, due to the weathering out of the fragments, as opposed to the reversed mode of weathering of the coarse tuff, in which the fragments stand out, is characteristic of the breccia, and particularly of that portion which had its origin through flowage. After the first peeling off of the concentric plates, the weathering becomes to a certain degree chemical, and the final result is a grayish, sandy soil, filled with fragments and boulders of the original rock. Schistose phases are rare, but such as exist suffer the same changes that were described in the case of the mashed coarse tuff.

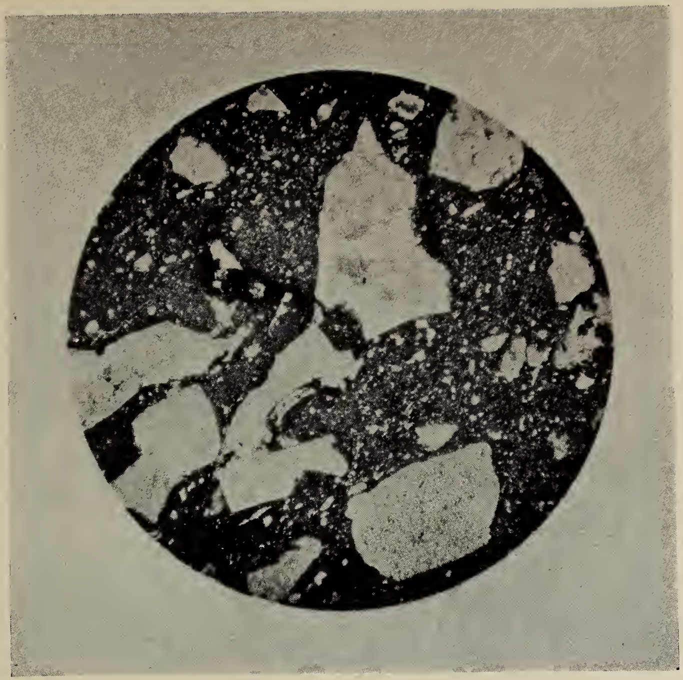
RHYOLITE.

Flows of rhyolite have their best development along Flat Swamp Ridge, where they appear upon the surface in narrow strips, forming the highest portions of the ridge. More or less schistose phases of the same rock occur here and there within the area of acid volcanic breccia; but in most cases these are represented by isolated outcrops and do not cover sufficient territory to show upon the geologic map. The rock in all its occurrences grades into a brecciated phase.

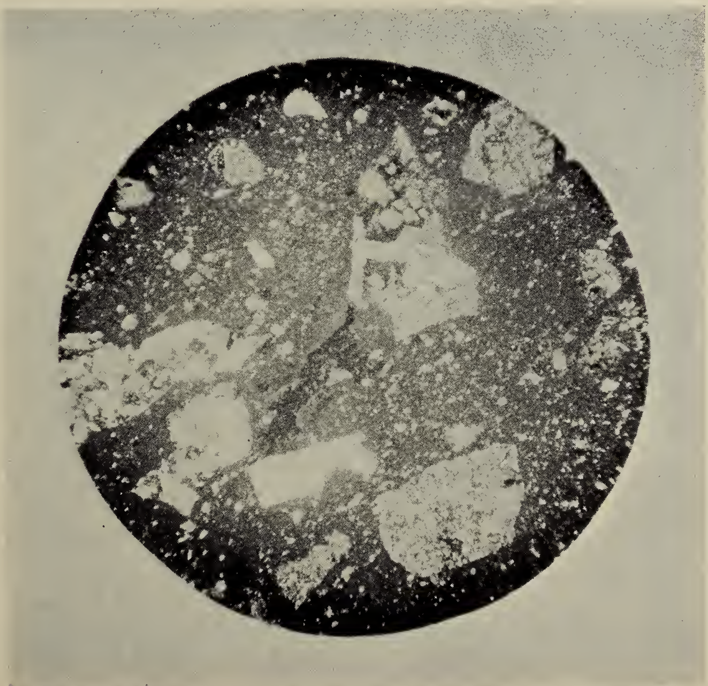
Macroscopic description.—In hand specimen, the rhyolite is a dense, black, dark green, or grayish-green, porphyritic rock, with a greasy luster on fresh fracture. It is quite brittle and breaks with a conchoidal fracture; forming slivers with keen, translucent edges. The rock is not very porphyritic; though it has a decidedly speckled or mottled appearance, which is due only in part to the phenocrysts, and more especially to the great number of loosened splinters which appear white and opaque by reflected light. The phenocrysts are uniformly distributed and may be seen to be elongated feldspar crystals of fair outline. Quartz phenocrysts are rarely present and are never prominent. Occasional small areas of dark green, chloritic material are visible, and sometimes specks and grains of pyrrhotite are prominent. Flow lines are developed in favorable places, but are best seen on weathered surfaces. (Plate X, A.) There are denser phases of the rock which are not apparently porphyritic and these may easily be confused with the silicified acid fine tuff. Part of the so-called "gun-flint" may be a very dense rhyolite. The average rhyolite is massive and somewhat jointed; in a few places it has suffered some degree of mashing. Its brecciated phase is classed as a volcanic breccia.

Microscopic description.—The microscope discloses phenocrysts of orthoclase, plagioclase, and quartz in a groundmass consisting of a pepper and salt mixture of quartz and feldspar.

Orthoclase occurs as phenocrysts in fair sized crystals of subhedral to anhedral habit, with a tendency toward a brick-like form. These are usually twinned according to the Carlsbad law, and often the edges are slightly rounded. The crystals frequently have a sort of shattered appearance, and certain of them are fragmental. In a section of a metamorphosed phase of the rock, the orthoclase was observed to grade into microcline. Inclusions are occasional small patches of calcite, sometimes epidote and brown biotite, and more



A. Photomicrograph of a fragment contained in the acid volcanic breccia, Davidson County, N. C. 30 diameters; ordinary light; showing fragmentary nature of components.



B. Same in polarized light, showing the angular and shred-like outline of the components.

frequently shreds of sericite. The feldspar is in no case perfectly fresh, but shows partial alteration to kaolin.

The plagioclase is somewhat subordinate in amount to the potash feldspars and occurs in smaller, subhedral crystals, which show albite twinning. Extinction angles prove these to be at the acid end of the series, and not more basic than oligoclase. They contain small indeterminable inclusions, and are partially altered to kaolin, yet on the whole appear fresher than the orthoclase.[1] The plagioclase, too, shows a certain amount of shattering.

The quartz rarely occurs in well-defined phenocrysts, but usually forms masses which show themselves between crossed nicols to be aggregates of interlocking grains of various sizes. These probably represent granulated phenocrysts, and sometimes suggest some degree of recrystallization since granulation. There are frequently uniformly distributed smaller anhedrons; and rarely a phenocryst of larger size with an embayment of groundmass may be seen. In some slides occur a certain amount of infiltrated chalcedonic silica, resembling spherulites.

Iron ore is present sparingly in grains and cubes. It is represented by both pyrite and pyrrhotite.

Irregular shreds of a brown, pleochroic biotite are present, and are apt to be in aggregations rather than uniformly distributed.

The groundmass is a fine-grained pepper and salt mixture of quartz and feldspar, containing a host of other minerals in variable but small amounts. Among them may be recognized irregular patches of calcite, areas of a pale green chlorite, occasional grains of epidote and clinozoisite, fibers of sericite, shreds of greenish biotite, and specks and grains of iron ore. Some kaolin is invariably present.

Texture.—The rock is porphyritic, consisting of phenocrysts set in a groundmass which is microgranitic. Occasional flow lines are present, and these are usually rendered visible by the kaolin dust. No spherulites or lithophysæ could be definitely recognized.

[1]The orthoclase in older rocks is frequently muddier than the plagioclase; but from this it must not be concluded that the first weathers more easily than the latter, for the reverse is true. See Lemberg, J. Zur Kenntniss der Bildung und Umwandlung von Silicaten. Zeit. d. Deut. Geol. Ges., v. 35 (1883): 575.

CHEMICAL COMPOSITION.

The chemical composition of the rhyolite is shown in column I of the following table. The analysis of a similar rock from the South Mountain district of Pennsylvania is included for comparison:

ANALYSES OF RHYOLITE AND RELATED ROCK.

	I		II
	a	*b*	
SiO_2	74.67	74.43	73.62
Al_2O_3	10.78	10.69	12.22
Fe_2O_3	1.25	1.23	2.08
FeO	2.11	2.11	4.03
MgO	trace	trace	0.26
CaO	1.47	1.51	0.34
Na_2O	5.31	5.47	3.57
K_2O	2.68	2.71	2.57
H_2O	0.59	0.63	----------
CO_2	1.30	1.30	----------
Ignition	----------	----------	0.40
Total	100.16	100.16	99.09

I. Rhyolite from Flat Swamp Mountain, Davidson County, N. C. Duplicate analyses. J. E. Pogue, Jr., Analyst.

II. Devitrified rhyolite from South Mountain, Pa. C. H. Henderson, Analyst. Williams, G. H., The volcanic rocks of South Mountain in Pennsylvania and Maryland. Am. Jour. Sci., v. 44 (1892), 493, 494.

The chemical analysis shows the rock to be a perfectly normal rhyolite.

Classification.—All the features indicate that the rock represents the devitrified remnant of an ancient rhyolitic lava flow. The rock is, therefore, classified a rhyolite or aporhyolite (devitrified rhyolite).

Variation.—A type of rock whose nature cannot be accurately determined, but which is probably either a devitrified rhyolite or a highly silicified acid fine tuff, will be briefly described. This rock is of special interest, as it contains grains and masses up to ¼ inch in diameter, of sphalerite, galena, chalcopyrite, and pyrite abundantly distributed without any seeming order or connection with lines of fracture. The rock occurs one mile northwest of the Emmons Mine, just east of the road which leads past Beulah Church. A little prospecting has been done here.

In hand specimen the rock is dark grayish-green, very dense and brittle, and breaks with a conchoidal fracture into chips with exceedingly keen edges. In addition to abundant areas of sulphides, there are thickly distributed minute white specks, suggesting incipient

A. HAND SPECIMEN OF RHYOLITE, SHOWING FLOW STRUCTURE MADE PROMINENT BY WEATHERING, FROM FLAT SWAMP RIDGE, DAVIDSON COUNTY, N. C.

B. HAND SPECIMEN OF A VERY DENSE AND HIGHLY SILICEOUS ROCK, CONTAINING ABUNDANT AREAS OF GALENA, CHALCOPYRITE AND PYRITE. THE SMALL WHITE SPECKS ARE MINUTE AGGREGATES OF GRANULAR KAOLIN. THE ROCK IS EITHER A SILICIFIED TUFF OR DEVITRIFIED RHYOLITE. FROM ONE MILE NORTHWEST OF THE EMMONS MINE, DAVIDSON COUNTY, N. C.

phenocrysts or crystals arrested in their development before taking on crystal outline. (See Plate X, B.)

The microscope reveals no definite clue as to the nature of the rock. The white specks, in hand specimen suggestive of phenocrysts, are aggregates or bunches of granular kaolin. The groundmass is very dense and composed of quartz and feldspar, with chlorite, epidote, clinozoisite, biotite, and kaolin. The feldspars include both orthoclase and plagioclase. There are occasional areas composed largely of quartz, with subordinate amounts of feldspar, epidote, chlorite, and grains of the sulphides, having a sort of interlocking appearance as if the mass had undergone recrystallization.

From the present evidence, no definite conclusions can be drawn as to the nature of the rock. If it be a rhyolite, however, it is of interest because containing such a variety and abundance of sulphides.

WEATHERING.

Due to its dense and massive nature, the rhyolite is very resistant to the forces of weathering. Its outcrops are consequently found in the highest portions of the district. These are light gray to almost white in color, because of a very thin film of decomposed material on the surface. This is very characteristic of the rhyolite (and of portions of the volcanic breccia). Occasionally flow lines may be visible on such surfaces, but are never prominently developed. The outcrops are usually rounded; sometimes they are angular due to the falling out of joint blocks. The final result of weathering is an arenaceous soil of light color. The rapidity of weathering is increased in the small portion of the rhyolite that has suffered mashing.

DACITE.

Dacite composes the hill east of Cid known as Kemp Mountain. It forms here an area of oval outline, about one mile long and ¾ mile wide.

Macroscopic description.—In hand specimen the dacite is a rather tough, grayish-green rock, with a slightly mottled surface. This is due to a few feldspathic phenocrysts and to specks and small patches of material resembling biotite and chlorite. Also small loosened chips on fresh fracture appear lighter in color than the massive rock and add to this characteristic. The rock is quite massive, little jointed, and occurs in numerous rounded masses, resembling the outcrops of rhyolite. A very close inspection reveals that many of the crystals resembling feldspar are green in color, probably due to an admixture of epidote.

Microscopic description.—Under the microscope the dacite is seen to be composed of badly altered phenocrysts of feldspar, set in a fine-grained matrix of quartz and feldspar, together with patches of biotite and chlorite, and grains of epidote.

The feldspar occurs in medium sized, badly altered phenocrysts of subhedral habit. Most of these are plagioclase, probably oligoclase running into andesine. The crystals are often almost entirely replaced by epidote accompanied by some chlorite. Alteration is to kaolin and sericite fibers.

Scattered through the rock occur patches of a green, pleochroic biotite, and areas of green chlorite, probably formed from the biotite. The two often appear identical in plane light, and are only distinguishable in polarized light by the ultra-blue color of the chlorite.

The groundmass is made up of grains of epidote, clinozoisite, and iron ores; dust-like particles of kaolin; sericite fibers, biotite shreds, and chlorite patches; and a large number of quartz anhedrons mingled with elongated feldspar crystals. Quartz appears to be almost as abundant as feldspar, and is frequently found in crystals of fair rhombic outline, with occasional slight embayments around the edges. Similar dihexahedral quartz crystals, showing a rhombic cross-section, have been described by Küch[1] as occurring in the groundmass of a dacite from South America.

Texture.—The rock is porphyritic, with a groundmass partaking of the character both of a microgranitic and pylotaxitic texture; microgranitic, because of a fine-grained mixture of quartz and feldspar; pylotaxitic, because composed of small feldspars with no glassy base.

[1]Küch, Richard. Petrographie (from Geologische Studien in der Republick Colombia). 1892: 69.

CHEMICAL COMPOSITION.

The chemical composition of the dacite may be seen in column I of the table. The analyses of two related rocks are introduced for comparison.

ANALYSES OF DACITE AND RELATED ROCKS.

	I	II	III
SiO_2	72.33	74.57	69.96
Al_2O_3	14.56	12.58	15.78
Fe_2O_3	0.15	2.77	2.50
FeO	2.22	n. d.	n. d.
MgO	0.91	0.30	0.64
CaO	2.55	0.35	1.73
Na_2O	3.40	3.98	3.80
K_2O	2.82	3.70	4.12
H_2O	0.30	1.04	1.53
CO_2	0.00		
Total	99.24	99.29	100.07

I. Dacite from Kemp Mountain, Davidson County, N. C. A. S. Wheeler, Analyst.
II. Dacite from Crimea, Russia. A. Lagorio, Analyst. Washington: Chemica analyses of igneous rocks, U. S. G. S., Prof. Paper 14: p. 153.
III. Dacite from McClellan Peak, Washoe, Nevada. F. A. Gooch, Analyst. *Ibid.*: p. 167.

Classification.—Although there are present no quartz phenocrysts, the other features and the chemical analysis combine in placing the rock among the dacites.

WEATHERING.

The dacite weathers in a manner very similar to the rhyolite. It is very resistant and stands out in abundant rounded outcrops. The weathered surface is usually of a light gray or yellow color. This discoloration often extends for an inch or so inward from the surface, where a rather sharp line of demarcation from the fresh rock within is reached. The soil is a light colored, arenaceous one, not appreciably differing from the rhyolite soil.

THE BASIC TUFFS, BRECCIAS, AND FLOWS.

ANDESITIC FINE TUFF.

A dense phase of the andesitic tuff occurs at only a few points amid the andesitic coarse tuffs and breccias. On account of its analogy to the acid fine tuff, it will be briefly described.

Macrascopic description.—In hand specimen the fine tuff is a dense, massive, rather tough rock, breaking with an irregular fracture. In color it is greenish, though upon closer inspection the surface is seen to be a mottled mixture of epidote green and dull purple.

Barely with the unaided eye, and easily with the hand lens, a few very small feldspar phenocrysts may be made out. Numerous specks of pyrrhotite are distributed through the rock.

Microscopic description.—The microscope shows the rock to contain a great number of ragged and broken feldspar crystals of small size, most of which show the albite twinning. A number of measurements showed these to be as basic as andesine.

The groundmass is composed of an interlocking mass of plagioclase fragments, with a few grains of infiltrated quartz. Numerous small epidote grains, and occasional aggregates of kaolin and patches of chlorite are also present. More rarely seen are actinolite needles, and patches of black material which probably represent iron ore or organic matter.

Classification.—The microscopic details alone would not be sufficient to classify the rock with certainty. Its occurrence in the field, however, where it is found grading into the andesitic coarse tuffs and breccias, when considered in connection with the details given above, suggests strongly that the rock is merely a fine-grained phase of the andesitic tuff.

WEATHERING.

The fine tuff is only fairly resistant to the forces of weathering. It forms a sandpaper surface of rounded outline and greenish or yellowish color. The decay proceeds from the surface and cracks inward, accompanied by a discoloration of the rock. The soil is a reddish one, less arenaceous than the rhyolite soil.

THE ANDESITIC COARSE TUFFS AND BRECCIAS.

No distinction is made between andesitic coarse tuff and andesitic breccia, because the two types are too intimately associated to be separately mapped. Under this combined heading, therefore, will be included all the dark colored and heavy andesitic rocks, whether massive or schistose, which show in hand specimen a fragmental nature, an exception to this being some very badly mashed facies, which require the use of the microscope to bring out their true nature.

The andesitic tuffs and breccias are abundant rocks within the district. They form bands, usually a fraction of a mile in width and several miles in length, alternating with the belts of the other rocks. These rocks are most prominently developed along the southwest border of Flat Swamp Ridge and at several points near the northeast edge of the district; they form the elevated area just west from Bald Mountain; and in a mashed condition compose a ridge beginning a mile northeast of Silver Hill. A large number of occurrences of smaller areal extent are found at numerous other points.

Macroscopic description.—This andesitic fragmental rock varies greatly from place to place. Indeed the field variations are more dissimilar than are the thin sections when seen under the microscope. There are certain characteristics, however, which are common to all phases, and these will enable one in most instances to recognize the rock.

In the first place, nearly all occurrences of the rock have a dark green color, almost an epidote green. But this color sometimes varies: on the one hand to a light grayish-green; on the other, to a dark bluish-black. Prominent in all, save extremely schistose phases, is the fragmental nature of the rock. Often it is made up almost entirely of green fragments. Sometimes the fragments appear less abundant and subordinate to the groundmass; at other times, they are quite small, and most of them have been converted into small areas of green, chloritic-looking material. In the extremely schistose phases the fragments can not be seen; though even here they often become visible upon the weathered surface. The extreme toughness of the rock, far in excess of any other rock in the district, is a feature especially characteristic of the massive varieties, and useful in recognizing them.

The typical massive phase of the rock may be described as follows: dark green; heavy; tough; composed almost entirely of green fragments one-fourth to three-fourth inches in diameter, some an epidote green, others darker; space between fragments filled with irregular areas of feldspar phenocrysts mixed with greenish material resembling biotite and chlorite; numerous small specks of pyrrhotite uniformly distributed; occasional specks of chalcopyrite; boundaries of fragments often indefinite.

A less abundant massive phase has the following characteristics: heavy; tough; composed almost entirely of dark green fragments up to one-half inch in diameter; space between fragments filled with irregular areas of white feldspathic material; occasional specks of epidote recognizable; rare grains of pyrrhotite and chalcopyrite.

A slightly mashed phase shows the following features: light grayish-green; fragments not prominent; contains small, irregular, dark colored areas apparently composed of chlorite; dark colored patches of calcite; very rare feldspar phenocrysts, visible only with hand lens; occasional fragments of a siliceous rock. One specimen contains a fragment 3 inches in diameter of a dense, dark colored, siliceous rock. The fragment contains specks of pyrrhotite along certain lines and in isolated positions, which have apparently derived their material from the fragment, as this had been bleached to a distance of one-fourth inch from each particle of iron ore. A peculiar mottled appearance is thus given the fragment. (See Plate XI, A.) A few specks of chalcopyrite occur with the pyrrhotite.

An extreme degree of mashing converts the rock into a greenstone schist; grayish-green to dark green; highly schistose; no fragments visible on fresh fracture; fragmental nature sometimes brought out on weathered surface; few specks of pyrrhotite.

Microscopic description.—The andestitic tuffs and breccias present a more uniform appearance in thin sections than in hand specimens. The microscope reveals in most cases a preponderance of greenish fragments over feldspar phenocrysts and groundmass.

The areas of groundmass form usually only a very small portion of the rock, and are irregular in outline, with frequent reëntrant angles and curves, as they fill in between the jagged edges of the fragments. The high power shows these areas to be an interlocking mass of feldspar, mostly plagioclase (probably oligoclase running into andesine). The feldspars near the edges of the areas tend to arrange themselves at right angles to the contact lines, and needles of actinolite run from the fragments into the feldspar. In addition, these areas contain grains and prisms of epidote, and often sericite fibers and kaolin dust. In many sections shreds and patches of biotite and chlorite occur in the groundmass.

In the few cases where phenocrysts of orthoclase are found between the fragments, these occur in subhedral to subangular forms, sometimes having slightly rounded edges. Zonary structure and undulatory extinction may be developed. Carlsbad twinning is also frequently seen. Inclusions are sericite fibers and shreds of biotite. The alteration product is kaolin.

Plagioclase forms more abundant phenocrysts and is found in elongated, subhedral crystals; also in ragged, angular, and rounded forms. These are sometimes bent and even faulted. Many show undulatory extinction and zonary structure. Sericite and kaolin occur as inclusions.

Quartz may be seen in some of the sections occurring in anhedrons or hexagonal crystals, but in no place does it appear to be a primary constituent. Irregular areas of chalcedonic silica may less often be seen.

Biotite of a brown-green color and strong pleochroism is frequently developed. The shreds occur around the fragments and phenocrysts, and sometimes even within the fragments. The biotite is considered secondary and to have been developed at the same time in both groundmass and fragments. Included rutile needles are occasionally present.

Chlorite occurs in patches and is probably an alteration product of the biotite.

Epidote, accompanied by some clinozoisite, occurs in grains and prisms. It is variable in amount; in some sections it forms the greater portion of the groundmass.

There is in some sections considerable amount of grayish-black, non-polarizing material, which occurs in areas and drawn out into lines which wrap about phenocrysts and fragments. This is in the main kaolin, and probably contains an admixture of organic matter. In other sections this material is of a gray color, here probably free from organic matter, and varies in amount present.

The fragments are quite varied and will merit a rather detailed description. It will be understood that all types of fragments are not found in any one occurrence of the rock.

Type 1. Andesitic fragment: composed of a mesh of plagioclase laths, some bent and twisted and some ragged and broken; all have the same general alignment; accompanied by epidote, calcite, and much chlorite; porphyritic and contains a few subhedral plagioclase phenocrysts; actinolite needles present; kaolin and chlorite so arranged in wavy lines as to suggest flow structure. The fragment undoubtedly represents an andesitic flow rock, with a pylotaxitic groundmass of a fluidal texture.

Type 2. Andesitic fragment: Same as type 1, but lacks trachytic arrangement of feldspar laths. Some of these fragments are packed full of actinolite needles.

Type 3. Andesitic (?) fragment: Dark green; composed of a multitude of actinolite fibers and occasional irregular feldspar crystals of indefinite outline, together with some epidote. This may represent a more altered phase of type 2.

Type 4. Amygdaloidal andesitic fragment: Contains numerous small, rounded or oval areas, usually filled with chalcedonic silica, biotite or chlorite, but sometimes filled with black material, probably a mixture of kaolin and organic matter; at times filled with grains of epidote and clinozoisite, or calcite; between the amygdules may be occasionally made out a feldspar lath, showing faint albite twinning. (See Pl. XI, B.) For the greater part the feldspars have been replaced by a veritable mesh of actinolite needles, which tend to be arranged at right angles to the amygdules and frequently run into them. This type of fragment is abundantly present in many of the occurrences. (See fig. 3.)

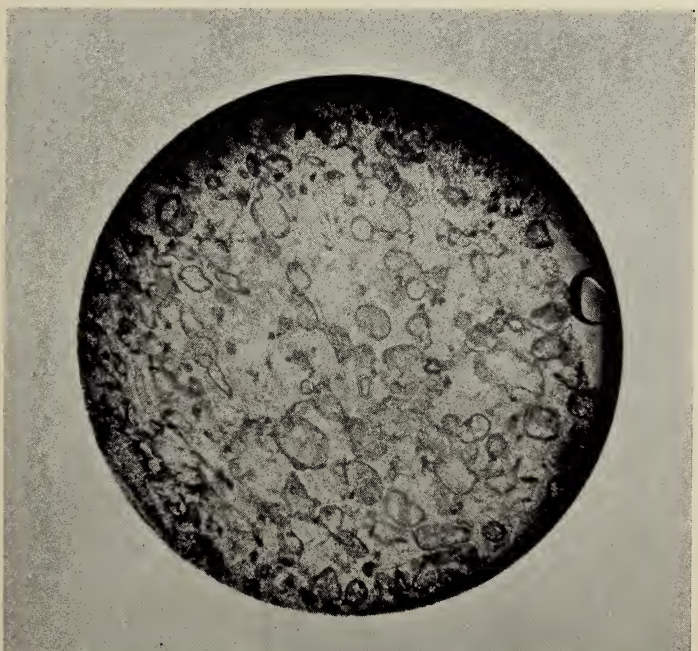
FIG. 3.—SKETCH SHOWING THE AMYGDULES WITHIN AN ANDESITIC FRAGMENT CONTAINED IN THE ANDESITIC BRECCIA. MAGNIFIED ABOUT 88 DIAMETERS.

Type 5. Acid fragment: Difficult to determine, but is highly feldspathic, with but an exceedingly small quantity of secondary ferromagnesian minerals, such as epidote, clinozoisite, and chlorite. A small amount of kaolin and a few prisms, probably apatite, can also be recognized. Some of the feldspars show albite twinning, indistinctly developed. No quartz can be discerned with surety. The fragment is probably a piece of flow or tuff of trachytic character.

TEXTURE.

The rock has a typical fragmental character, in which rock fragments and broken feldspar phenocrysts are indiscriminately mingled in a fine-grained groundmass of a more or less pylotaxitic nature.

A. HAND SPECIMEN OF ANDESTIC BRECCIA WITH INCLUDED ACID FRAGMENTS. THE LIGHT COLORED STREAKS AND SPOTS IN THE FRAGMENTS ARE "ZONES OF GROWTH" FROM WHICH SMALL SPECKS OF IRON ORE HAVE EVIDENTLY DERIVED A PORTION OR ALL OF THEIR MATERIAL.



B. PHOTOMICROGRAPH OF AN AMYGDALOIDAL FRAGMENT CONTAINED IN THE ANDESITIC BRECCIA; 105 DIAMETERS; ORDINARY LIGHT.

Very striking is the fact that certain phases of the rock, which appear schistose in hand specimens, fail to show this feature under the microscope. This is especially noticeable where the cavities of an amygdaloidal fragment have remained round or oval and show no signs of elongation, even though the rock may have had a considerable degree of schistosity imposed upon it. This indicates a period of sufficient length, subsequent to the formation of the vesicles and before the mashing of the breccia, to permit the infiltration and filling of the cavities; otherwise they could not have resisted the compressive force inducing schistosity. Some variations show the effects of mashing by the bending of the groundmass around the fragments, forming a kind of "augen" structure; and by the flattening and parallel alignment of the secondary minerals. In general, the amount of secondary material, such as epidote, biotite, chlorite, etc., increases with the degree of schistosity.

CHEMICAL COMPOSITION.

A partial chemical analysis of a typical specimen of the massive andesitic breccia is shown in column I of the following table. Part of an analysis of a similar rock is given for comparison.

ANALYSES OF ANDESITIC BRECCIA AND RELATED ROCK.

	I	II
SiO_2	50.07	52.35
CaO	8.21	8.16
Na_2O	3.05	3.17
K_2O_2	0.38	0.88

I. Partial analysis of massive andesitic breccia from west of Bald Mountain, Davidson County, N. C. A. S. Wheeler, Analyst.
II. Andesite from Siebengebirge, Prussia. (Analysis partially quoted.) Analyst not stated. Washington: Chemical analyses of igneous rocks, U. S. G. S., Prof. Paper 14: p. 285.

The analysis given corresponds to that of a rather basic andesite.

Classification.—The rock may, without question, be classified as andesitic in nature. Whether it be a mica-, augite-, or hornblende-andesite cannot be definitely stated. It very probably varies, however, from an acid to a basic andesite, having no exact values within these limits. In certain instances the rock is transitional into an acid or felspathic phase of breccia, and some phases might more aptly be called trachy-andesites; but such are grouped under the general heading. It may be that through a decrease in the number of andesitic fragments and the consequent increase in phenocrysts and ash of an acid nature, a transition into the acid series of tuffs and breccias is accomplished. Some occurrences in the field strongly suggest this. No specimens of the rock, however, appear to be more basic than a basic andesite.

WEATHERING.

The weathered surface of the fragmental andesite is quite distinctive. In general the rock forms a bumpy or billowy surface of grayish, grayish-green, or brownish color. The bumps are rounded, without steep slopes, and often the entire surface has a sandpaper-like appearance and feel. A certain degree of schistosity accentuates these features; the massive phases have them to a less degree; the very schistose phases likewise show them but to a limited extent. Frequently the surface may in addition have a sort of porous structure, as if the more soluble portions of the rock had been removed.

The original dark green color is due chiefly to chlorite, biotite, and epidote. The weathered surface assumes a grayish color in proportion as these constituents are decomposed and carried away by solutions, and the kaolin, resulting from the decay of the feldspars, is left behind. The soil is argillaceous in nature, often forming a sticky clay. Its color varies through numerous shades of buff and red. Where the rock is richly mineralized with pyrite and pyrrhotite, as is the case near Bald Mountain, the soil is a brilliant red.

The contour of the weathered outcrop is a good criterion of its degree of schistosity. Massive phases form rounded outcrops of a variety of shapes, which are never very narrow or elongated. Schistose varieties form narrow, elongated outcrops, resembling cockade hats.

ANDESITE.

The flow andesite does not have a wide distribution within the district. Its best development is a narrow band, crossing the Fairmont-Denton road near the Mountain Schoolhouse; and a broader area upon the southwest end of Three Hat Mountain.

Macroscopic description.—There are two distinct phases of the rock; the one amygdaloidal, the other massive; each of which is characterized by a green color and great toughness. The latter, of course, lacks the oval and rounded cavities, usually filled with greenish material, which are characteristic of the former.

The amygdaloidal phase is an epidote green rock, abundantly dotted with rounded and elliptical spots, varying in diameter up to 4 mm. These are the amygdules and are filled with material of a darker green color, which appears in most cases to be epidote with chlorite, but sometimes in part calcite. The groundmass is so dense that nothing of its content can be made out with the unaided eye. Near the surface the material filling the cavities has weathered out, giving the rock a honey-combed appearance. (See Plate XII, A.)

The massive andesite in hand specimen presents certain characteristics which render it easy of identification. It is a fine-grained rock, varying in color from a grayish-green, or epidote green mottled with blue, to a dark bluish-purple. All variations contain small green specks and masses of epidote. Except in the densest specimens, the rock is easily seen to be porphyritic; the phenocrysts are feldspar laths of variable abundance. Upon close scrutiny the striated character of the crystals may often be seen. The nature of the dark green groundmass can not be determined, even with the aid of the hand lens. In one specimen the epidote is so arranged in lines as to give to the rock a banded appearance, suggestive of flow structure. The andesite occasionally contains minute grains and crystals of pyrrhotite.

Microscopic description.—The microscope shows the amygdaloidal andesite to be composed of the following minerals: plagioclase, biotite, chlorite, epidote, calcite, clinozoisite, actinolite, and iron ore.

Plagioclase is porphyritically developed in the form of a few subhedral crystals of slightly larger size than the feldspars of the groundmass. It is extremely abundant in the groundmass, where it occurs as small, slender, badly altered laths, with poor crystal outline. Around these and binding them into a confused aggregâte are fibers of a pale green actinolite. Albite twins are abundant, but accurate measurements can not be obtained. Such as could be made showed the feldspar to be hardly more basic than andesine. Inclusions are indeterminable; the product of alteration is kaolin. The feldspar is not found within the amygdules.

Biotite is abundantly present within the amygdules, and is of an olive green color, strongly pleochroic. It occurs in shreds which are grouped in some instances in the interior of the amygdules; in other instances they line the walls. They have no definite orientation, either in respect to the walls of the amygdules or to one another. Biotite is not present in the body of the rock.

A pale green chlorite occurs in abundance in the amygdules, and sparingly in the groundmass. It is of a scaly nature, and often between crossed nicols the field is at no time black, but a brownish color, due to a compensation between the confused aggregate of edges. Frequently also the mass appears essentially isotropic, caused by its excessively fine division. In the amygdules the chlorite occurs in the center, or lining the walls, or even at times filling the entire cavity.

Calcite is an abundant constituent of the amygdules, and occurs either in association with the other minerals, or alone filling the cavity. It shows polysynthetic twinning parallel to (0112).

Epidote and clinozoisite occur both in the amygdules and in the groundmass. Within the amygdules there is an abundance of clinozoisite, showing an abnormal blue interference tint, together with a lesser amount of epidote with higher birefringence. Often the same crystal will show a gradation from the higher colors of the epidote into the ultra blue of the clinozoisite, and this gradation is usually from within outward. The two minerals are indistinguishable in plane light. They have usually a well-defined crystal outline and frequently twinning parallel to (100) may be seen. Also a cleavage parallel to (001) is well developed, often meeting at an angle in the twinned portions; a second cleavage parallel to (100) is often distinct. The crystals are elongated parallel to the b-axis, and cross-sections of these are abundant. Epidote and clinozoisite may be grouped about the edges of the amygdules or may occupy the interior of the cavity. Grains of these minerals are present in the groundmass.

Iron ore is very sparingly present within the amygdules, occurring in small, irregular grains, usually associated with the chlorite or biotite. It is also present in small specks in the groundmass.

The groundmass is composed of a confused aggregate of plagioclase laths, bound together by numerous shreds and needles of actinolite. Abundantly interspersed through this mass are small grains and crystals of epidote and clinozoisite, and an occasional small mass of chlorite.

The massive rock contains essentially the same minerals as the amygdaloidal variety. Plagioclase is abundantly present as phenocrysts of a tabular, subhedral habit, with an occasional slender lath-shaped form. The variety is basic oligoclase, running into andesine. A certain amount of infiltrated quartz is present, filling areas between the minerals. Epidote, with associated clinozoisite, occurs in rather large, irregular masses which are not uniformly distributed; and as small grains or granules. Biotite is abundantly scattered throughout the sections. It occurs filling in between feldspars and often forms areas about them. A small quantity of iron ore is also present. The groundmass is a fine-grained aggregate of epidote, plagioclase, iron ore, and probably sericite fibers.

Trachytic variation.—In two occurrences of the rock just described—a fine-grained phase forming a small hill about 1 mile west from Three Hat Mountain, and a porphyritic phase occurring east of Kemp Mountain—small quantity of orthoclase could be recognized. In the fine-grained occurrence, this was mostly represented by microcline showing its characteristic "grating" structure. In other respects these rocks, though badly altered, were andesitic. They very probably represent a trachytic phase of the andesite, and perhaps might properly be called trachy-andesites.

TEXTURE.

The massive rock is typically porphyritic, with a groundmass of pylotaxitic texture. The amygdaloidal phase has also a pylotaxitic groundmass.

CHEMICAL COMPOSITION.

The chemical composition of the massive andesite is shown in column I of the following table. The analyses of several related rocks are included for comparison.

ANALYSES OF ANDESITE AND RELATED ROCKS

	I		II	III	IV
SiO_2	66.21	66.28	65.58	59.24	60.41
Al_2O_3	10.62	10.62	15.79	13.84	16.88
Fe_2O_3	6.44	6.41	0.94	5.46	--------
FeO	2.12	2.11	2.44	1.36	6.07
MgO	0.94	1.15	1.47	4.79	2.82
CaO	3.22	3.17	3.08	5.60	5.93
Na_2O	6.11	6.09	2.58	3.13	6.72
K_2O	1.71	1.73	5.67	4.22	1.02
H_2O	0.61	0.61	1.16	2.02	--------
CO_2	1.48	1.47	--------	--------	--------
Total	99.46	99.64	--------	--------	--------

I. Andesite from one-half mile east of Healing Springs, Davidson County, N. C. (Duplicate analyses.) J. E. Pogue, Jr., Analyst.

II. Trachyte from Mount Amiata, Tuscany. J. F. Williams, Analyst. Washington: Chemical analyses of igneous rocks, U. S. G. S., Prof. Paper 24: p. 171.

III. Trachy-andesitic breccia from Highwood Mountains, Mont. Hurlbut and Barnes, Analysts. *Ibid.*: p. 223.

IV. Amphibole andesite from Panama. Analyst not stated. Rosenbusch: Elemente der Gesteinslehre: p. 306.

It is seen that the rock is chemically related to the three types given above. The small percentage of alumina present is noticeable; this indicates a magma low in that compound. The relation of the alkalis is the strongest andesitic character brought out by the analysis. This will tend to place the rock among the andesites, although it has a strong alkalic caste.

Classification.—From a strictly chemical viewpoint, the rock is so alkalic that it might be called a trachy-andesite, or even a trachyte, with perhaps as much propriety as an andesite. But in the natural classification, where so much depends upon the nature of the feldspars, the fact that orthoclase is subordinate to a plagioclase running as basic as andesine renders the rock more properly an andesite.

It is recognized that the andesitic flows and breccias tend to become alkalic and trachytic in nature. In view of this, it would not be surprising if further work in other portions of the "Slate Belt" should show up flows of typical trachyte.

WEATHERING.

The andesite is fairly resistant to the forces of weathering, but not to such an extent as the acid flows and breccias. It yields more readily to chemical than to physical alteration, so that concentrically weathered boulders and outcrops of a brownish, grayish, or dirty yellow exterior are formed. The surface of the massive phases often has a rough, granular appearance and feel, comparable to coarse sandpaper. In the amygdaloidal phases, the filling of the amygdules is readily removed, so that the surface assumes a cellular or honeycombed structure which is quite distinctive. The outcrops of either variety are usually small; where jointing is developed small, rounded boulders abound. The soil resulting from the complete alteration of the andesite is a more or less arenaceous clay, which is characterized by a reddish color.

DIKE ROCKS.

Gabbro and diabase are prominent within the district in the form of dikes. Gabbro is older than diabase, but younger than the other formations which it cuts. The diabase is of Triassic age.

GABBRO.

Gabbro occurs abundantly throughout the district as enormous dikes, trending in a northeast-southwest direction. These are al-

A. HAND SPECIMEN OF THE AMYGDALOIDAL ANDESITE. THE AMYGDULES MAY BE PLAINLY SEEN WITH A HONEY-COMED MODE OF WEATHERING.

B. LARGE ROUNDED BOULDERS OF GABBRO WHERE A GABBRO DIKE CROSSES THE FAIRMONT-DENTON ROAD ONE MILE NORTHWEST OF HEALING SPRINGS, DAVIDSON COUNTY, N. C.

ways in conformity with the schistosity and their introduction seems conditioned by this easy line of yielding. The rock shows upon the surface in the form of large and small, rounded, yellowish boulders, distributed in lines following the direction of the dikes. (Plate XII, B.)

Macroscopic description.—In hand specimen the gabbro appears a greenish-gray, massive rock, varying according to the locality from a medium fine grain, in which the component minerals are distinguished with difficulty, to a medium coarse grain, in which crystals of green hornblende are easily recognized. The average rock is seen to be composed of a light green ferromagnesian mineral, with a satiny luster, surrounded by white, opaque feldspar. With the hand lens, and in the coarser specimens, with the naked eye, the crystal faces of the green mineral may be plainly seen, and in favorable places its fibrous nature becomes apparent, while the feldspathic constituent fails to reveal definite outline. The rock is extremely tough, being knit together by its fibrous constituents, but is moderately soft, so that when an edge is struck with the hammer it inclines to mash to a whitish mass rather than to flake off.

Microscopic description.—In addition to the feldspar and fibrous hornblende, the microscope reveals epidote, clinozoisite, iron ore, chlorite, sericite, etc.

The feldspar is too badly altered to admit of its determination. It has completely changed into a confused aggregate of grains, scales, and fibers; among which may be clearly recognized grains and crystals of epidote and clinozoisite and fibers of uralitic hornblende. Sericite and kaolin are probably present, but cannot be determined with certainty; and other secondary products may be included. This alteration of the feldspar is that of saussuritization, and only an occasional outline of a feldspar lath remains to indicate its former presence. The feldspar is considered to have been rich in lime to give the products mentioned above.

The chief ferromagnesian mineral is a hornblende, which is represented by the pale green, faintly pleochroic, fibrous variety known as uralite. This occurs in slender needles, having either a parallel or nearly parallel arrangement, or forming an interlocking mass, which becomes at no time dark between crossed nicols. There are also massive crystals of a pale green hornblende, which do not show a fibrous nature, but which are probably made up of closely packed bunches of uralite fibers. These often show twinning parallel to the front pinacoid (100), and at times several twinned lamellæ may be seen in the same crystal. These massive crystals, like the fibrous ones, lack good crystal outline, and string out into the saussurite. The hornblende is considered largely, if not entirely, a secondary product from pyroxene.

The iron ores occur in a few widely scattered brownish to black grains, most of which are partly, and some entirely, altered to leucozene. They may be either ilmenite or titaniferous magnetite.

The epidote and clinozoisite occur with gradations, the one into the other; frequently the same grain is part epidote and part clinozoisite. The two are abundantly scattered througout the sections; their more usual occurrence is in the shape of irregular grains, although a prismatic form is not uncommon. The moderately high birefringence of epidote and the two abnormal interference colors of clinozoisite serve to distinguish the two.

A small amount of calcite is present in irregular patches, with which is associated occasional masses of chlorite of a pale green color, scaly nature, and low double refraction.

TEXTURE.

The gabbro is essentially a mixture of saussurite and uralite, in which fibers and crystals of uralitic hornblende are imbedded in a mass of saussuritized feldspar. The age relations of the components need not be noted, since they are formed from previous constituents, whose relative ages are of course obscured by the result. For the same reason no special textural characteristics of gabbro are seen.

Classification.—Although the rock is completely altered from its original state, its field occurrence, macroscopic and microscopic features render it safe to classify it as an altered gabbro.

WEATHERING.

The abundant jointing in the gabbro allows the easy access of solutions, and concentrically weathered boulders are readily formed, which are found both loose and imbedded in the surrounding soil. Their surface is a yellowish, more or less pitted one, composed of clay-like material stained by iron oxide. The outer rim of this material varies in thickness through various small fractions of an inch, and beneath this there is a gradation into a mass of a lighter color, which shows the interlocking fibrous structure of the ferromagnesian minerals from between which the feldspathic constituents have departed, leaving somewhat of a porous structure. The inner rim is not so thick as the outer and in turn grades into the normal rock beneath. The process of weathering carried further gives a slightly porous, yellow, clay-like mass, of rather firm constituency and little grit, called locally "soapstone," and which has been dug at a number of places for use as linings to fireplaces, and is said to have been shipped to Gold Hill and Silver Hill for use as furnace linings. The final product of weathering is a yellowish to a rusty red, more or less plastic clay, with little grit. At times in road cuts, ravines, and the like, this retains the original jointing of the gabbro.

DIABASE.

Diabase forms narrow dikes uniformly, though not abundantly, distributed throughout the district. It shows upon the surface as narrow lines of rounded boulders of an iron rust color, which indicate the trend of the dikes. It is the youngest rock in the district, for it cuts the other formations, including the gabbro. Moreover, it is considered of Triassic age, as dikes of a similar rock are found on the edge of the "Slate Belt," cutting both slates and Triassic sandstone.

Macroscopic description.—The diabase is a massive, fine-grained, dark blue rock, with a faint purplish tinge and a more or less waxy luster. To the unaided eye it appears a closely knit aggregate of dark colored minerals, showing numerous small crystal faces. With the hand lens it is possible to recognize occasional striated feldspars, and to distinguish from these the darker colored ferromagnesian minerals. The olivine and augite, however, cannot be separated.

Microscopic description.—The microscope reveals the following minerals, named in the probable order of their formation: iron ore, olivine, plagioclase, augite. (See Plate XIII, A and B.)

The feldspar is basic labradorite, probably running into bytownite, and makes up about 45 per cent of the rock. It occurs in long, slender laths of subhedral habit. The albite twinning is universal, in combination with which is occasionally found a Carlsbad twin. Zonary structure is not pronounced. Inclusions consist of small particles of iron ore and rare shreds of biotite. In the sections examined the feldspars were quite fresh.

Augite, the most common ferromagnesian constituent, forming about 35 per cent of the rock, is of a pale green color and non-pleochroic. It rarely shows crystal outline, but surrounds and encloses the feldspars, forming a matrix in which the feldspars are arranged at random. Iron ore is found as inclusions, and the alteration product, of which there is little, is a pale green, scaly mineral, probably antigorite.

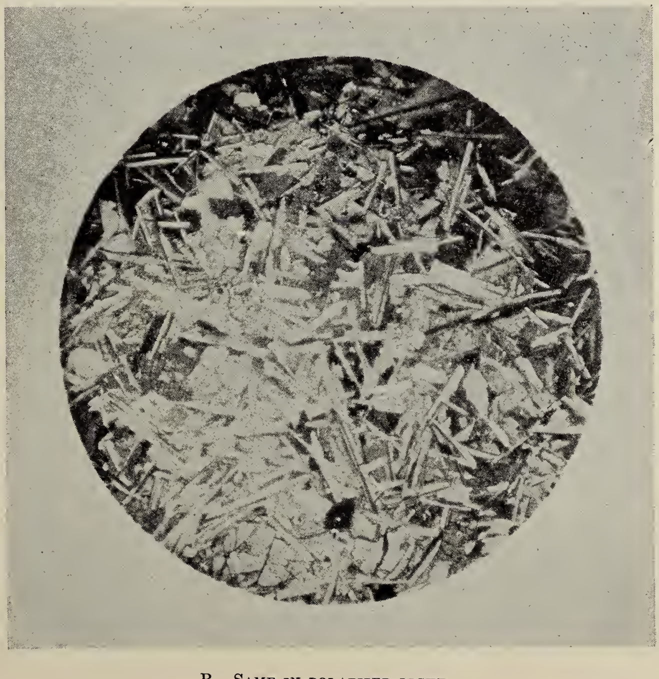
Olivine is present to the extent of about 17 per cent, an unusually large amount, and forms rounded crystals or grains of a very pale color. It includes particles of iron ore, and upon weathering forms what appears to be talc, rather than serpentine, the more common alteration product of olivine. This mode of weathering differs from the more usual form, in that the weathering is not confined to the cracks of the mineral with the segregation of iron ores, but proceeds independently of cracks and is not necessarily accompanied by iron ores.

The iron ores are abundantly scattered through the rock, but prefer the company of the ferromagnesian minerals, particularly olivine. They occur in both grains and specks, and rarely show good crystal outline.

TEXTURE.

The diabase is an excellent example of the ophitic texture: *i. e.,* the long, slender feldspar laths are arranged at random, moulded around which is the augite, in most cases without definite crystal outline. The olivine mostly holds its own form against that of the feldspar, but in some cases it includes or partly includes a feldspar lath. Thus it appears that the olivine in part crystallized previous to the feldspars and in part the crystallization was simultaneous. The sections show that the rock has suffered but an insignificant amount of alteration.

A. PHOTOMICROGRAPH OF DIABASE, DAVIDSON COUNTY, N. C.; 30 DIAMETERS; AUGITE, OLIVINE, PLAGIOCLASE AND MAGNETITE, OPHITIC TEXTURE. ORDINARY LIGHT.



B. SAME IN POLARIZED LIGHT.

CHEMICAL COMPOSITION.

The chemical composition of the diabase is given in column I of the following table. In column II the composition as calculated from the mode is given. The analyses of two related rocks are included for comparison.

ANALYSES OF DIABASE AND RELATED ROCKS.

	I	II	III	IV
SiO_2	47.66	46.4	46.63	45.80
Al_2O_3	19.24	18.1	14.40	18.49
Fe_2O_3	1.83	1.3	2.85	4.90
FeO	8.67	7.7	8.06	5.67
Mgo	10.79	12.1	7.25	5.75
CaO	9.91	12.8	9.28	12.70
Na_2O	1.14	1.5	2.47	3.20
K_2O	0.26	--------	0.70	0.60
H_2O	0.06	--------	--------	--------
Total	99.56	100.0	--------	--------

I. Chemical analysis of diabase from near Fairmont, Davidson County, N. C. A. S. Wheeler, Analyst.
II. Microscopic analysis of the above specimen. J. E. Pogue, Jr., Analyst.
III. Chemical analysis of diabase (auvergnose), Mt. Ascutney, Vt. W. E. Hillebrands, Analyst, Washington. Chemical analyses of igneous rocks, U. S. G. S., Prof. Paper, 24: p. 329.
IV. Chemical analysis of diabase, Sudharz, Germany. O. Schilling, Analyst. Roth, Justus. Bietrage zur Petrographie der plutonischen Gesteine (1873): p. 22.

The determined and calculated compositions shown in columns I and II are in fair accord. These also agree pretty well with the two analyses given for comparison. The most important point of difference is the magnesia present. The greater percentage in numbers I and II is accounted for by the presence in them of an unusually large amount of olivine high in MgO.

Classification.—The rock exhibits all the properties of an olivine-diabase, and it is classified as such.

WEATHERING.

The diabase resists weathering as well as any rock in the district. It forms, however, concentrically weathered boulders with a yellow or rust-colored exterior. This coating of clay-like material stained with iron oxide is only a very small fraction of an inch in thickness and beneath is revealed the fresh rock. The soil resulting from the complete decomposition of these boulders is a yellow or rust-colored clay with very little grit.

CHAPTER IV.

PHYSIOGRAPHY.

INTRODUCTION.

North Carolina is naturally divided into three physiographic belts or provinces: to the east, the flat lying Coastal Plain; to the west, the mountainous Appalachian Region; and between these, intermediate in elevation, the Piedmont Plateau. The last contains the district under consideration.

This area in general presents the surface features common to the Piedmont Plateau. It is a region of mature topography, with well rounded hills, gently sloping valleys, and graded streams ramifying into a network of streamlets that leave no portion of the area undrained. Locally there are exceptions to the above statements, such as narrow ridges with steep, rocky slopes, and valleys with gorges and courses of rapids.

RELIEF.

The lack of a topographic map renders the description of the elevations only approximately correct. The survey of a proposed railroad to be built parallel to the Yadkin River, which forms the southwest boundary of the district, gives a few accurate points, however, which will serve as a basis for the approximations.

The elevation in the road near Von Cannon's store at Fairmont is 645 feet above sea level. The northwest bank of Abbott's Creek, near the crossing of the Fairmont-Bringles Ferry road, is 595 feet. The surface of ordinary water in Flat Swamp Creek, at a point about 100 feet from the edge of the river, is 576 feet. The summit of a saddle-shaped depression about seven-eighths of a mile south of Jacksonhill and on the road to Stokes Ferry is 689 feet.[1] The range of elevations within the district is estimated to be about 200 feet. This range may be encompassed by long, almost imperceptible slopes, undisturbing the general appearance of subdued relief; or by sudden rises, with rugged topography as a result.

The most striking feature of the entire area is Flat Swamp Ridge (Pl. I.) Rising abruptly from the Yadkin River to a height of

[1]For these figures acknowledgment is due Mr. O. H. P. Cornell, Chief Engineer of the Winston-Salem Southbound Railway Company.

about 200 feet, and extending as a narrow ridge for nearly 7 miles in a northeast direction, it forms a natural barrier, crossed by few roads. It divides the district almost equally, and, since it is visible from nearly all points, will serve as a kind of datum point to which the other surface features may be referred.

A narrow road finds scant room around its southern end, between the river and the precipitous rocky ascents up to Flat Swamp Mountain. This name is given to that portion of the ridge which extends with a wavy crest for about $3\frac{1}{2}$ miles to Healing Springs, where it becomes sufficiently subdued for a road to cross. A half mile of small eminences brings the ridge to another depression, from which there rises Grice Mountain, of conical outline, with steep slopes on all sides. This is in turn succeeded by a narrow ridge of less height, known as Surratt Mountain, which dies out in the course of a mile or so in a country more generally hilly than that near the river. At any point, save in the depressions which are used to advantage for roads, it is difficult to cross. Enormous rocks rising tier upon tier often present sheer precipices of stone. Upon the eastern slope of Flat Swamp Mountain especially is this the case. The western slope is more gentle for a third of the ascent, when a sort of terrace is reached, which leads to the steeper portion. Upon this terrace there are a number of smaller elevations, forming ridges subordinate in extent to the main ridge.

To the east from the top of Flat Swamp Mountain is presented a bird's-eye view of a low lying country, appearing from this height quite flat. Several miles distant, beginning beyond the confines of the present area and extending as far as the eye can reach, rise many ridges, separated by valleys of rolling country. Descending from the hill and going eastward, one finds a country of but little relief for a mile or so, until there appear a few rounded hills and a few low, mound-like ridges. In the extreme southeast corner of the area, near Lick Creek Church, the land begins to rise by gentle ascents. A little used road leads around near the Yadkin River and to an elevated plateau-like area, from which there is a splendid panoramic view of the entire Gold Hill country. Just to the east rises Bald Mountain, a pointed hill like an inverted cone, of about the same elevation as Flat Swamp Mountain.

To one going west from Flat Swamp Mountain, the difference between valley and ridge is not decided. The region is made up of long, gentle slopes, forming well rounded, almost imperceptible divides between broad valleys. In such a type of country Fairmont and Silver Hill are situated.

The portion of the area 10 miles or so removed from the Yadkin River becomes pre-eminently a region of ridges and rounded hills, to which the stretches of level country are much subordinate. The ridges here, like Flat Swamp, have a northeast trend, but none continue for long distances, and many have little, if any, elongation. Three Hat Mountain, the most prominent of these ridges, has its beginning a few miles northwest of Cid, and extends beyond the area mapped. It is composed of three elevations, in nearly a north-south alignment, connected by saddle-like depressions, and resembling the crowns of three derby hats; from which resemblance the name was probably suggested. Just to the west of Three Hat Mountain is a rather prominent ridge, to which no name has been given. A mile northeast of Cid, Kemp Mountain rises gently, with a steep descent toward Lick Creek. Viewed from the latter point, it appears a narrow ridge; seen from near Cid, it seems a less striking elevation. Just off the area beyond Kemp Mountain begins a series of narrow ridges, rising to a height of several hundred feet.

Summary.—There is an intimate relation between the surface configuration and the nature of the underlying rocks. An examination of the ridges reveals that these without exception are composed of harder and more resistant rock than are the lower country and valleys. In a word, the geology and topography are in agreement. Hence it is believed that the present surface configuration is the direct result of the ordinary processes of weathering which are now going on, and by virtue of which the least resistant formations have been eaten into, and the harder ones thrown into relief.

DRAINAGE.

The Yadkin River is the master stream which receives the drainage of the area. It crosses the region from northwest to southeast, cutting through hard and soft formations alike. It has found even Flat Swamp Ridge no barrier and has formed through it a narrow, V-shaped passageway. That the river was present long before Flat Swamp Ridge was brought into relief by the carving action of the elements seems an inevitable conclusion. Hence we call the Yadkin an antecedent or superimposed stream.

Of quite a different order are the principal streams that directly drain the district. Unlike the Yadkin, these conform to the underlying rock formations; finding it much easier to carve their valleys in the slate and mashed tuffs than in the harder breccias and flows. Unable to cut through ridges, they remain parallel and flow in a southwest direction. These, therefore, may be called consequent streams, as they have been developed in consequence of the underlying rocks. Abbott's Creek, Flat Swamp Creek, Lick Creek, and Cabin Creek are the important streams of this kind.

Flat Swamp Creek is the largest of the four. It enters the area already a fair sized stream, and when it flows into the Yadkin it is 30 to 40 feet in width. It varies greatly in the amount of water it carries: in times of little rain, the stream is shallow and sluggish, and exposes a multitude of rocks along its bed; during periods of heavy rain it often becomes a veritable torrent, flooding the adjoining lowlands, destroying crops, and washing away bridges. It follows a direction agreeing in general with the trend of the geological formations. Entering the district near the Silver Hill Mine, it flows in a southwest direction through both flat lying and hilly country, and finds its way past Flat Swamp Ridge, which in some places rises rather steeply from the eastern bank. Indeed its banks are largely steep and rocky. In its whole course, the stream seeks out boundary lines between rock formations of different kinds.

Abbott's Creek is only slightly smaller than Flat Swamp Creek, and is a similar stream. It enters the area about 2 miles west of Silver Hill and passes one-half mile east of Fairmont. It follows the usual southwest direction until, within a mile of the river, it deserts the trend of the slates and flows southeast across this formation, entering the Yadkin at a sharp angle at a point near the mouth of Flat Swamp Creek. The jointing that is prominently developed here or a possible fault plane may be the determining influence in controlling the course of the stream.

Lick Creek and Cabin Creek are somewhat the counterparts of Flat Swamp and Abbott's Creeks. They follow more or less parallel courses, agreeing with the trend of the schistose formations, though having minor variations in the more massive phases. Cabin Creek enters the district near Jacksonhill and flows into the Yadkin a mile north of Bald Mountain. Lick Creek is nearer and parallel to Flat Swamp Ridge. Two tributaries of equal size make up the latter stream; the one passes just to the east of Kemp Mountain, the other flows near its western edge. The two join a short distance south of this elevation.

In addition to the four streams just mentioned, two of which flow the length of the area, there are a multitude of small tributaries and branches, which include all directions in their various courses. These deserve little detailed notice, save that they are controlled more by the surface configuration induced by the four major streams than by the structural and geological nature of the underlying formations. Buddle Branch, a tributary flowing south from Silver Hill into Abbott's Creek, will serve as an example. This stream cuts at a small angle across an area of slate standing on edge. It is believed that in this and similar instances the proximity of the larger stream has overcome the tendency of the smaller to follow the structure: this may be aided by a system of joint planes, or possibly by minor faults. One stream in particular seems to owe its direction to faulting or important jointing. This is Fourmile Branch, a tributary to Flat Swamp Creek, which pursues a remarkably straight course mostly in massive formations for the 6 miles of its extent. Two large diabase dikes coincide with the stream, whose course is, moreover, parallel to possible faults indicated on the geological map. These features suggest strongly, if they do not prove, that this stream follows either fault or joint planes. Most of the smaller streams, however, do not show such regularity.

Summary.—To sum up, the streams of the district are of three orders: first, the master stream or that conditioned by a previous topography; second, the streams depending upon the structure and hardness of the underlying rock; and third, the streams and streamlets which flow into those of the second class, and are controlled by their proximity to them, though in part consistent with the structure and the geological formation. The drainage, therefore, has been developed to its present stage through the application of the three sets of conditions outlined above.

PHYSIOGRAPHIC HISTORY.

The present surface of the region, when analyzed in its relation to the kind and condition of underlying rock, presents certain lines of evidence or clues as to its previous condition. From these can be deduced the topographic changes which have taken place and the order in which they have occurred.

When the great series of slates, tuffs, breccias, and flows, which compose the district, were compressed and thrown into enormous folds, a complex surface was formed, the nature of which we can only conjecture. This was attacked, perhaps even during its formation, by the forces of erosion; and denudation was carried to such an extent that the region was beveled across hard and soft formations alike and reduced to a condition of practically no relief; or technically, to a peneplain. Upon this surface, lying near sea level, an entirely new system of drainage was inaugurated by a slight elevation or tilting of the land. This system, of which the Yadkin is the remnant, was not controlled by the underlying rocks, because these lose their influence near sea level, but probably was conditioned by the nature of the tilting. At any rate, as evidenced by the Yadkin, the main direction of this drainage was in a northwest-southeast line and directly across the hard and soft formations.

The establishment of this line of drainage was followed by a progressive elevation of the land, during which the surface was thrown into relief and a struggle was carried on: on the part of the drainage, to maintain its original direction; on the part of the slowly rising land, to divert the drainage from its anomalous course into conformity with the structure. That the land was not sufficiently energetic in elevating itself to offset the downcutting of the streams is shown by the present position of the Yadkin River, which flows through a narrow gap in Flat Swamp Ridge. The river succeeded in downcutting at a rate slightly in excess of the elevation. That the two opposing forces were almost matched is suggested by the present course of rapids within the gap, which excessive downcutting on the part of the river would have prevented.

During the contest between Flat Swamp Ridge and the Yadkin River, or in a broader sense between the rising Piedmont Plateau and the master drainage, the chemical and mechanical forces of weathering were busy in their attacks upon the region. Streams subordinate to the Yadkin were developed which found their easiest path in agreement with the structure. These carved out northeast trending valleys, separated by ridges, and gave rise to a host of smaller dependent streams. Thus, as a result of the elevation of the land and the downcutting of the streams, the present surface configuration was developed.

SURFACE CONFIGURATION OF THE VARIOUS FORMATIONS.

Many of the rock formations of the district form distinctive kinds of surfaces. Certain rocks will predominate in valleys; others will compose the ridges. The different rock types will therefore be enumerated, accompanied by brief statement of their dominant surface form.

Slate: Forms valleys, gentle slopes, well rounded divides. Never prominent on uplands and ridges. Massive and mashed phases form about same type of surface.

Acid fine tuff: Occurs as narrow bands in other formations and is controlled by their surface forms. Mostly low lying country.

Acid coarse tuff: Stands up higher than slate. Forms minor ridges. Usually intermediate in height between slate and acid volcanic breccia. Forms terrace on west side of Flat Swamp Ridge. When schistose, has about same surface configuration as slate. When narrow intercalations in other rocks, is controlled by them.

Acid volcanic breccia: Together with the rhyolite forms the most prominent ridges of the region. Called locally "mountain rock." Surface always covered with enormous boulders and rounded outcrops. Mashed phases form lower surfaces, but the rock is predominantly massive.

Rhyolite: Shares with acid breccia the property of forming the highest ridges. Ridges usually narrow, with steep slopes. When schistose, differs little from coarse tuff or slate.

Dacite: Stands up nearly as prominently as rhyolite. Kemp Mountain has a more rounded appearance, with gentler slopes, than the rhyolite and breccia ridges, such as Flat Swamp Ridge.

Andesitic tuffs and breccia: Form rather prominent ridges, which are not so narrow or steep as the ridges of acid rock. Ridges may have little or no elongation. Form elevated, well rounded, plateau-like regions as west of Bald Mountain. Massive and slightly schistose phases act much the same. Badly mashed phases and narrow beds conform to topography of adjacent rocks.

Andesite: When narrow, does not form prominent surface features. When associated with basic breccia, as on Three Hat Mountain, forms prominent ridges.

Gabbro dikes: When large, form low, well rounded, mound-like ridges. When smaller, have little influence on topography or form slight depressions.

Diabase dikes: Too small to have appreciable topographic effect. Largest apt to be slightly depressed.

CHAPTER V.

STRUCTURE AND METAMORPHISM.

INTRODUCTION.

Previous chapters deal with the nature of the rocks of the district, and their relations to one another. In them it has been possible to identify and classify the rocks, though they have been profoundly changed both chemically and physically since their original consolidation. It is the purpose of the present chapter to discuss these changes—features not inherent in the rocks themselves, but which have been imposed, during the vicissitudes the region has undergone, by the forces that have operated. Thereby is afforded evidence for deducing the nature of the forces and the order in which they acted; and thus the sequence of events or geologic history is arrived at.

STRUCTURAL FEATURES.

FOLDING.

The region has been squeezed into great folds during a period of severe compression, the most evident effect of which has been the mashing of many of the rocks into schists. The folds may not be directly observed, but their presence is inferred from three concurrent lines of evidence.

1. Bedding planes, which indicate a former horizontal extent often depart from this direction, and have a variable dip either to the northwest or to the southeast, and at times are even vertical. Were these sufficiently well preserved, they alone would indicate the exact nature of the folding; but they are much obscured by schistosity and weathering, so that only here and there can a measurement be obtained. Certain generalizations, however, may be made. Bedding planes are predominantly horizontal along certain northeast-southwest lines in massive formations; and tend to be vertical or nearly so in the badly mashed belts.

2. The surface outlines of the formations, best seen on the geologic map, are indicative of folding. In general, the formations may be divided into two classes: first, those which appear upon the sur-

face, as long, narrow strips, which gradually pinch out at the ends and never end abruptly against other formations; and second, those which occur in broad lenses and oval areas, of little or no elongation, often ending abruptly against other formations. There are of course no hard and fast lines in such a division. Many of the narrow bands are flow rocks or tuffs and breccias, which must have been deposited in layers or beds of horizontal extent. Their surface outline seems to preclude any other possibility than that they are the upturned edges of such beds, which now intersect the surface vertically, or nearly so. Broader lenses and oval areas, although often composed of the same rock as the narrow strips, can hardly have the same underground relations. If these, too, represent the edges of beds and consequently expose their cross-section, the abrupt endings of such formations and the great fatness of many of the lenses are difficult features to explain. Besides, the predominance of horizontal bedding near such formations is quite incompatible with such an idea. A satisfactory explanation lies in the consideration of these areas as occurring on the crests of great folds. This position allows of a most irregular surface shape, with abrupt endings against other formations, when planation has exposed a particular bed to view; and is moreover in accord with existing bedding planes.

3. The relation between schistose and massive formation throws further light on the structure. Schistosity is not developed alike in all parts of the area; it appears to have had a selective action, so that some belts are predominantly massive, whereas others are badly mashed. This might be explained by a difference in nature of the formations, by virtue of which certain ones were more susceptible to mashing than others. But such a view leaves unexplained why such rocks as the andesitic breccia and acid fine tuff, for instance, are so massive in some places, and in others form the most highly schistose rocks of the district. It would seem, therefore, that the position of a rock was a much more imporant factor in determining its degree of mashing than its nature. It follows, accordingly, that, although the region as a unit was subjected to compression, some portions were so situated as to escape any important effects of such a force, whereas others received the full effect of dynamic metamorphism. The crests of folds would afford positions favorable for the transmission of a great force, without important molecular adjust-

ments; the limbs would involve a greater slipping between beds and consequently would be susceptible to the greatest degree of mashing. This assumption best fits the facts observed.

The three lines of evidence concur in making pretty conclusive proof that the region is folded. The exact nature of the folding is a more difficult thing to determine. Yet an application of the same three principles indicates that the region very probably represents in general two anticlines and one syncline, the axes of which extend in a northeast direction in agreement with the schistosity.

The crest of one anticline is supposed to pass to the east of Fairmont and the Silver Hill Mine: along this line the formations show upon the surface as broad irregular lenses, which do not pinch out at the ends; the bedding, though much obscured, seems predominantly horizontal; and the formations are on the whole more massive than mashed. The crest of a second anticline probably includes Jacksonhill, Denton, and Kemp Mountain: along its axis the bedding varies little from the horizontal; the formations are not attenuated, but of round or oval contour; and the rocks are more or less massive. Flat Swamp Ridge is considered the trough of the syncline between the two anticlines: bedding is not sufficiently developed here to be of importance; but the formations are mostly massive and form extremely long and narrow strips, suggestive of the upturned edges of beds. Moreover, the most highly schistose rocks of the district are not characteristically found along the three lines mentioned; but in places between them which correspond to the limbs of the folds. The evidence, while not conclusive, is sufficiently strong to render this interpretation quite probable.

Consequent upon the major folding, a series of subordinate crumplings and crinklings were of necessity formed; but these have been so obscured by weathering and other changes as to baffle detection. Their presence is only indicated by an occasional bedding plane out of all accord with other measurements in its vicinity.

It is probable, also, that the major folds are not absolutely horizontal, but pitch slightly, so that their crests form wavy lines. No direct measurements of pitch can be obtained, but inference as to its nature may be made from the way in which certain formations end abruptly against others, as if dipping beneath them. A further evidence is the occasional discordance between trend of bedding and of schistosity, indicative of a complexly folded region.[1]

[1] Van Hise, C. R. Principles of North American Pre-Cambrian geology. 16th Ann. Report, U. S. Geol. Survey (1895): 629, 630.

In addition to these major and minor directions of folding, whose axes form a horizontal plane, the whole region has perhaps been slightly bent around a vertical axis. A glimpse at the geologic map will disclose the tendency of the formations and the schistosity to form an arc-like arangement; in general, varying from a northeast trend near the river to a more northernly direction as the upper limits of the map are approached.

MASHING.

It has been suggested in the previous section how schistosity, by virtue of which a rock tends to break more or less perfectly along a certain plane, has been induced upon much of the region by the same compression which occasioned folding, and how this has been more prominently developed on the limbs of the folds than on the crests or in the troughs. A further deduction, however, may be made from the nature of the schistosity; and that is the direction along which the compressive force acted. The average trend of schistosity is N. 50° E. Theoretically, therefore, the compression acted along a line passing N. 40° W., as the effects of compression are at right angles to the force.[1] This figure must not be taken as exact, for other factors would complicate the result; but it is approximately correct.

The average dip of the schistosity is about 70° to 80° to the northwest. There are extremely few cleavage planes dipping to the southeast; such as do are invariably steep, about 80° to 85°. This is significant. It suggests that the folds are not upright; in such a case approximately half of the schistosity should have a dip to the southeast. Thus there is evidence for believing that the folds are slightly inclined, their axial planes agreeing in a general way with the average dip of the schistosity. This view is consistent with the arc-like arrangement of the formations, which in itself implies a slight overriding of the upper crust and an axial dipping of the folds toward the center of the arc.

The northwest dip of cleavage planes and northwest facing concavity of the arcs is the opposite of conditions holding in the Appalachians. This may be due either to some undetermined local cause, or to an actual reversal of the relations between land and sea obtaining in the Paleozoic; so that in the case of the present

[1]See in this connection: Haug, Emile. Traite de Geologie. Vol. 1 (1907): 227.

area, the higher segment or land mass was to the northwest, whereas, in the case of the Appalachians, as is generally accepted, the higher segment or "hinterland" of Suess was to the southeast. The district under consideration, however, is too limited in size to afford widespread generalizations on this point, unless corroborated in the future by other observations in the slate belt.

A diagram has been made (see Plate XXV), showing the trend of all observations upon schistosity. This will be discussed in connection with joints, which have been likewise plotted.

JOINTING.

Joint planes are distributed throughout the district in all formations, but are most abundant in areas of massive rocks. In general, the degree of jointing decreases with increased schistosity, the two features seeming to be complementary. Where bedding is horizontal, jointing is invariably well developed.

These three features are quite in keeping with the hypothesis of folding, and are consequently an added bit of evidence in favor of this structure. The jointing is considered to be largely the result of the compressive force which threw the region into folds and mashed many of the rocks into schists. Those rocks, which were situated on the crests or in the troughs of folds, escaped to a large degree the effects of mashing; but in transmitting the force were themselves broken into blocks bounded by joint planes.

The significance of the jointing and its relation to other structural features can best be shown graphically. To this end a number of diagrams have been prepared.

In diagram 1 (Plate XIV) the trend and number of all joints observed in the district are plotted on rectilinear coördinates. The vertical directions or ordinates represent the number of observations; the horizontal directions or abscissæ indicate the trend of each joint plane. Thus at a glance may be seen the number of joints trending in any given direction; for instance, 14 joints have a strike of N. 20° W., etc. The black curve indicates the jointing in the slate; the green curve, the total jointing in the district. The difference between the two curves gives, of course, the joints in all other formations than the slate. The greater number of observations in the case of the slate is due to its greater areal extent.

From diagram 1 (Plate XIV) the following facts appear: There is no important difference in the jointing in the slate and in the other formations; the jointing is grouped in four important sets, in their order of importance as follows:

N. 5° W. to N. 30° W.=25° range.
N. 65° W. to N. 85° W.=20° range.
N. 15° E. to N. 35° E.=20° range.
N. 70° E. to N. 85° E.=15° range.

In diagram 2 (Plate XIV) are plotted, in the same way and on the same scale, the diabase dikes (in red), and the quartz veins (in black). From this is seen the regular variation of the dikes from N. 50° W. to N. 50° E.; and the tendency of the quartz veins to be grouped between the directions N-S. and N. 45° E. The rather regular variation for the curve of the veins, in which the maximum directions of trend are spaced 15° apart, is interesting. The exact significance of this, however, does not appear.

In diagram 3 (Plate XIV) the schistosity is represented, on the same horizontal scale, but on a vertical scale reduced one-fourth. The relation between trend of schistosity and that of jointing is strikingly brought out. There are few joints parallel to the schistosity; so that the curve of the latter is complementary to the curve of the former. The quartz veins are seen to have their greatest development in a position intermediate to that of maximum schistosity and maximum jointing. Many of the veins, indeed, cut the schistosity at a very small angle.

To show more visibly the relation between schistosity, jointing, and the direction of the compressive force, the previous diagrams (Plate XIV) are in a measure combined in one diagram (Plate XV). In this the various features are plotted on a circle, whose circumference represents the different points of the compass. The curve for total jointing in diagram 1 is transferred to the circle and plotted on polar coordinates, so that by reference to it the relative number of joints with any given trend may be ascertained. This brings out four maximum lines of jointing represented by the four purple lines. The four sets of important joint directions appear by constructing segments to contain the maximum areas included by the joint curve. These of course are the same as those obtained in diagram 1 (Plate XIV); and each is bisected by the maximum line of jointing in purple. The directions of greatest schistosity are taken from diagram 3 and plotted on the circle in red. The heavy black line represents the average direction along which the compres-

DIAGRAM 1, SHOWING DIRECTION AND ABUNDANCE OF JOINTING. BLACK CURVE = JOINTING IN SLATE. DOTTED CURVE = JOINTING IN ALL FORMATIONS INCLUDING SLATE.

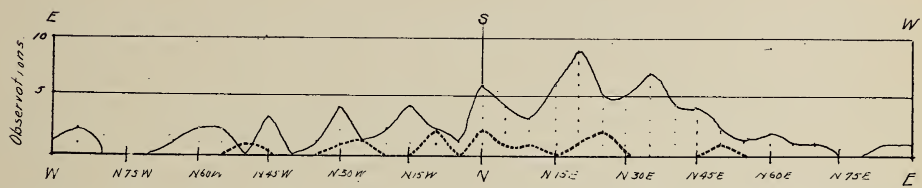
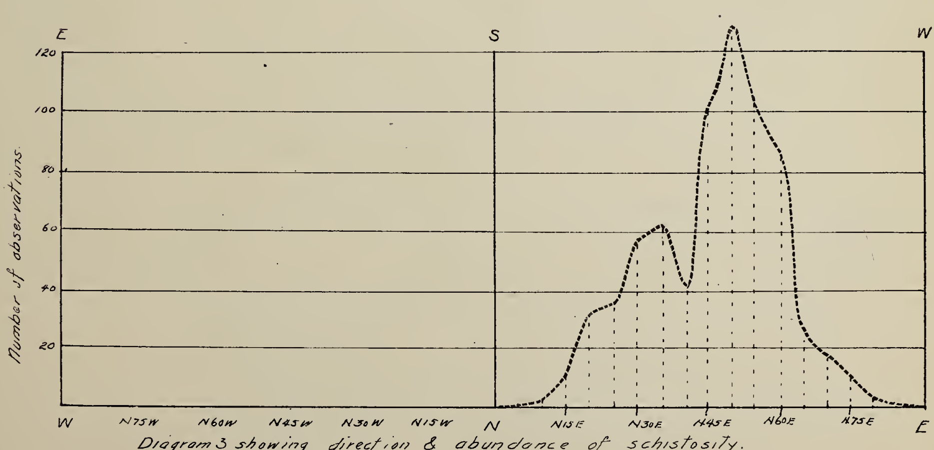


DIAGRAM 2, SHOWING DIRECTION AND ABUNDANCE OF QUARTZ VEINS AND DIABASE DIKES. DOTTED CURVE = DIABASE DIKES AND BLACK CURVE = QUARTZ VEINS.



DIAGRAMS SHOWING RELATIONS OF JOINTS, VEINS, DIKES AND SCHISTOSITY. ORDINATES = ABUNDANCE (NUMBER OF OBSERVATIONS) AND ABSCISSÆ = TREND.

sive force acted; it is given its theoretical value—*i. e.,* at 90° to the maximum schistosity.

Certain features are brought out rather clearly by this diagram. Also certain details invite some speculation. The four major joint sets are grouped two in the northwest quadrant and two in the northeast quadrant. Those in the northwest quadrant are of the greater importance; they are separated from each other by an angle of 35°, which includes the direction of compression. This double set seems to be largely the result of the compressive force, inasmuch as the maximum line of each (in purple) is inclined 20° and 35° to the line of compression; and because jointing from compression is developed in the lines of shear, which are inclined 45° or less to the force producing them. The double set of joints in the northeast quadrant may be explained in several ways. They cut the schistosity at small angles and the line of compression at large angles. They may be due to the same compression that induced schistosity; if so, this necessitates a degree of shortening involved in compressing the diamond in the northwest quadrant into the shape of the diamond in the northeast quadrant. They may be the result of a secondary force from the northeast or southwest, either an independent one or a component of the major compression. Perhaps a combination of all these acted. There is no evidence for believing any important jointing on the crests of folds to be due to tension: joints from such a cause would be parallel to the schistosity developed on the limbs of the folds.[1]

It must be understood that all jointing in the region is not considered the result of a single period of compression and folding. There is doubtless jointing from other subsequent earth movements. It does seem probable, however, that the most prominent jointing is consequent upon folding.

FAULTING.

While there is at no place conclusive evidence of faulting on an important scale, a number of possible faults have been indicated on the geologic map. These can not be verified by field observations; but their presence is suggested by the abrupt ending of certain formations, as if cut off by dislocations, and in cross-section by the failure of bands to be repeated on corresponding parts of folds. The smaller

[1]Van Hise, C. R. Principles of North American Pre-Cambrian geology. 16th Ann. Rept., U. S. Geol. Survey (1895): 669.

faults have a general parallelism to one another, and to Four-mile Branch, which pursues a remarkably straight course for 6 miles and agrees in direction with two large diabase dikes. They are also roughly parallel to the strike of a profound fault a few miles to the west, which Laney[1] has shown separates the slate series from a large area of igneous rocks.

A large overthrust fault has been indicated as extending along the eastern border of Flat Swamp Ridge in a northeast direction and becoming northernly in trend near the upper borders of the map. Its presence seems necessitated by the way in which broad belts of rock appearing on the western slope of Flat Swamp Ridge are not repeated on its eastern declivity, as would be expected on the two limbs of a syncline. Either, then beds 1-2 mile or so in thickness must pinch out along their dip in the course of a mile or they must be abruptly cut off by a fault. The latter conception is the simpler. A glance at the structure-section sheet (Plate IV) will make this idea clear.

The faulting is probably the result of the same compressive force, which induced folding, schistosity, and jointing. It is possible, however, that the coming to place of great granitic batholiths a few miles to the west may have exerted sufficient compression to occasion overthrust faulting on a large scale. Certainly this event very likely produced minor faulting and shattering.

INTERPRETATIONS OF STRUCTURE.

MOST PROBABLE INTERPRETATION.

The reasons have already been presented for believing the region to be made up of a series of inclined folds, whose axial planes dip steeply to the northwest. This interpretation is represented on the structure-section sheet (Plate IV), which shows cross-sections at several points across the district. By means of these, the underground relations of the rocks which appear upon the surface are indicated. In a general way, the cross-sections are what might be expected to be exposed, were great trenches cut across the region.

While the major features of the structure seem established with some probability, there are minor features upon which no direct evidence can be obtained; yet which must be expressed upon the structure-section sheet in a definite manner. It must be remembered,

[1]Laney, F. B. The Gold Hill mining district of North Carolina. A Thesis. Yale University 1908): 112.

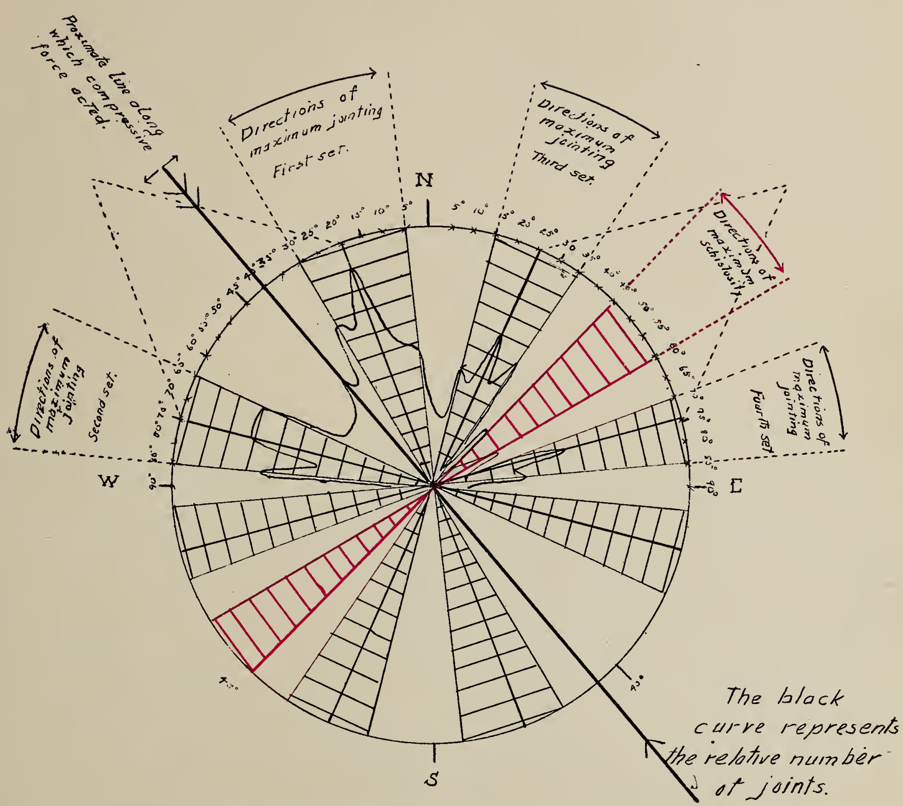


DIAGRAM SHOWING RELATIONS BETWEEN COMPRESSIVE FORCE, SCHISTOSITY AND DIRECTIONS OF MAXIMUM JOINTING. THE MAXIMUM LINE OF JOINTING FOR EACH SET IS THE RADIAL LINE.

therefore, that a diagrammatic representation is ideal and from the nature of the case expresses only in a summarized manner the conditions which exist in nature and omits an infinity of detail, whose inclusion would only serve to confuse.

In the cross-sections given, no minor crumplings are indicated on the major folds. Such undoubtedly exist, but they are omitted both for the sake of simplicity and because their nature is not known. The thickness of those beds, whose cross-section in no place is exposed to the surface, is entirely hypothetical: the thickness given in each case is considered a probable one, from which, however, the true thickness may depart rather widely. If it be attempted to trace out each formation as it is successively brought to the surface by the folding, it will be found that the beds do not always match on the opposite limbs of the folds. This is understood, if it be accepted, that the original horizontal extent of the formations consisted of a complicated interfingering of beds and lenses, and was not a succession of regular beds of the same thickness throughout their lengths. In such a case it would not be expected that folding would necessarily repeat similar beds on corresponding parts of folds. Along Flat Swamp Ridge, however, this explanation seems inadequate, inasmuch as beds of great thickness must pinch out with extreme rapidity in order to avoid repetition. In order to obviate this difficulty an overthrust fault has been introduced as a simpler explanation. The arc-like surface trace of this supposed fault plane renders it probably an overthrust consequent upon the northwest compressive force of folding. The fault plane may itself be folded, depending upon whether the slip occurred at the beginning or near the end of the period in folding. In the cross-sections the latter conception is prefered, because simpler.

The manner in which the major folds pitch is inferred from the abrupt endings of many formations along the crests of the folds, precluding a horizontal entension of this line.

ALTERNATE HYPOTHESES.

Although the interpretation of structure given appears to best fit the facts; some alternate hypotheses, especially in regard to the subordinate features, may be mentioned.

As suggested in previous paragraphs, the entire structure may be explained without the use of faults. This necessitates the pinching out of beds of great thickness within very short distances.

A portion of the rocks may have been brought into the region by an overthrust fault; and these subsequently interfolded with the regional rocks.

The region might possibly represent a series of isoclinal folds, with parallel limbs.

That the region may not be folded and represents a very thick deposit, which has been tilted and whose edge is now cut across by the plane of erosion, seems hardly a possibility.

METAMORPHIC FEATURES.

TEXTURAL CHANGES INVOLVED IN MASHING.

The textural changes imposed upon the rocks by compression have been discussed in various parts of the chapters descriptive of the rocks. It was there seen how nearly every rock type varies from a massive condition to a schistose state, having had induced upon it in some parts of its areal extent a certain degree of cleavage or schistosity, by virtue of which the rock breaks rather easily along definite planes. Sericite schists are the products of the extreme mashing of the acid series of rocks; greenstone schists have in the same way been derived from the basic series of rocks.

MINERALOGIC CHANGES INVOLVED IN MASHING.

From a microscopic study of massive and mashed phases of each rock type, certain minerals are seen to increase in abundance with the degree of mashing. These have apparently been developed, therefore, as a result of compression. Descriptions of such secondary minerals formed through dynamic metamorphism have been given in various parts of chapter III on Petrology, but it may be well to summarize these statements in this place. The following minerals appear to be largely or partly the result of dynamic metamorphism: sericite, biotite, chlorite, actinolite, epidote, and clinozoisite. Sericite is the most abundant secondary mineral in the acid series of rocks, so that the end product of mashing is a sericite schist. In the acid rocks are also found smaller amounts of biotite, chlorite, epidote and clinozoisite. These four minerals, with actinolite, are specially characteristic, however, of the basic series. Most of them are abundantly present in the greenstone schists, which result from the extreme mashing of any of the basic rocks. Chlorite is a close accompaniment of biotite, and the biotite in many cases passes into it. Likewise the epidote and clinozoisite always occur associated, and the epidote alters to clinozoisite. The last two, and perhaps actinolite also, are probably only in part due to dynamic metamorphism.

SILICIFICATION.

An important feature of the district is the highly silicified nature of many formations. This is indicative of a period during which large amounts of silica were brought in and deposited. The quartz veins now exposed probably represent the trunk channels along which silica-bearing waters moved. The mineralization and segregation of ores is also considered a result of the same general period.

DETAILED DISCUSSION OF GEOLOGIC HISTORY.

IGNEOUS ACTIVITY.

The geologic history of the Cid Mining District may be considered as having its beginning during a period of volcanic activity. This must have extended through a very long time—hundreds of thousands or even millions of years—during which there were innumerable alternations between quiet upwellings of lava, forming surface flows; explosive activity on an enormous scale, piling up to a great thickness deposits of tuffs and breccias; and periods of comparative quiescence, accompanied by a certain amount of weathering and erosion and the deposition of the slates. Between successive outbreaks, the magma probably underwent some degree of differentiation so as to give rise to more acid rocks at one time, and more basic rocks at others. It seems pretty probable that there were frequent swings between two not very diverse extremes, and that at no time did the products depart far from the general type, which is a rather acid magma rich in soda. Perhaps each important outbreak poured forth rhyolitic, intermediate, and andesitic materials.

It would be impossible to picture the details of this volcanic activity. It is suggested, however, that the outbreaks were largely fissure eruptions, breaking up through the series of already formed horizontal rocks at frequent points in the entire volcanic region. It must not be thought that any one volcanic cone, comparable to a modern volcano, gave rise to such widespread volcanic phenomena.[1]

[1]See Hague, Arnold. Early Tertiary volcanoes of the Absaroka Range. Pres. Add., Geol. Soc. Wash. (1898): 1–25.

SEDIMENTATION.

All of the slate and much of the fine tuff give evidence in bedding planes of deposition by water. The coarse tuffs and breccias may be air-laid or water-laid, or both. The flows may have taken place upon the surface of the land or under water. Possibly the entire series represents an off-shore deposit, with submarine volcanic activity alone or accompanied by outbreaks upon the shore. The region may also represent a river flood-plain deposit. Nothing remains to decide definitely between the two hypotheses.

It is believed from chemical evidence that the slate material was transported from no great distance. Hence a probable view is to consider the volcano-sedimentary series a basin deposit, the material for which was derived from beneath an area of limited extent, and the thickness of which was limited only by the depth of the "magma reservoir" and the amount of material extruded; so that by isostatic sinking of the crust block capped by a layer of volcanic and sedimentary rocks, as more material was forced up through it and deposited upon its top, a series of great thickness could have been formed, without drawing materially upon the surrounding country for sediments and conversely without bestowing evidences of its nature upon regions not within its own confines.

CONSOLIDATION.

However laid down, the tuffaceous and sedimentary rocks must have undergone cementation or consolidation before they were capable of being thrown into folds. This process doubtless accompanied the formation of the deposits, so that within a short period of geologic time after the cessation of volcanic activity, the series had been transformed into strata of hard rock. The rapidity with which this may be accomplished is seen by comparison with the ashes ejected by modern volcanoes, which are at times known to "set" or harden within a few days of their deposition.

FOLDING AND THE DEVELOPMENT OF SCHISTOSITY, JOINTING, AND PROBABLE FAULTING.

No evidence is afforded for estimating the length of time which intervened between the formation of the rock series and its folding. It may be that the compression put an end to the constructive epoch;

or it may equally be that this force was long deferred. At any rate, the region of horizontal beds and lenses was powerfully compressed by a force acting in a northwest-southeast line; the effects of which were folding, mashing, jointing, and faulting.

These four features have been sufficiently discussed in previous parts of this chapter.

INTRODUCTION OF GABBRO DIKES.

Following, after an unknown interval, the mashing or development of schistosity, a great number of gabbro dikes were insinuated into the region, following cleavage planes as easy lines of entrance. These are undoubtedly later than the folding, because they are controlled in direction by the schistosity and are themselves unmashed. The dikes represent either the outliers of an independent gabbro batholith or the differentiated offshoots from a large "magmatic reservoir" of a more acid nature.

A few miles to the west of the Cid district, and forming the western boundary of the entire slate belt, occur areas of granitic, dioritic, and other igneous rocks, which cover many hundred square miles. These are undoubtedly intrusive batholiths into the slate series. They do not, however, represent a single intrusive mass, which has become differentiated to the extent of forming areas of granite, diorite, etc. In the Gold Hill region Laney[1] has shown that granite is intrusive into diorite; also that dikes of gabbro cut the diorite but not the granite. Thus there seems to have been a period, following the folding of the slates, when great masses of igneous rocks were intruded into the region. While there were independent intrusions, all were probably the result of a single period of activity and all perhaps originated from the same "magmatic reservoir."

In view of these considerations, and because gabbro is found in the Gold Hill district intermediate in age between great intrusions of diorite and granite, the gabbro dikes of the Cid district are considered to have originated during a period of intrusive igneous activity and to be related to the igneous rocks a short distance to the west.

PASSAGE OF HEATED SOLUTIONS.

Previous to the approach of the great igneous masses, heralded by the introduction of the gabbro dikes, there is no evidence of pro-

[1]Laney, F. B. The Gold Hill mining district of North Carolina. A Thesis. Yale University (1908): 121; and N. C. Geol. and Economic Survey, Bull. 21, 1910.

cesses sufficient to account for widespread mineralization and silicification; unless, indeed, the original rocks be considered sufficiently rich in silica and metallic elements to permit of important concentration by ground-water circulation. Yet many formations have been enriched "en masse" by silica, while none show signs of depletion of this compound. Moreover, numerous quartz veins evidence a further amount in excess of what the rocks themselves seem competent to contribute. On the other hand, vapors and waters, with their burden of metallic elements, excluded by the great igneous masses which probably undermined the region, and certainly approached it, seem quite capable of having occasioned widespread silicification and mineralization; forming quartz veins along lines of major circulation and enriching places favorable for deposition by the formation of ores.

This subject is considered in greater detail in Chapter VI under the genesis of the ores.

OPERATION OF A SECONDARY FORCE, INDUCING MINOR JOINTING.

There is some evidence that, following the deposition of the ores, there operated a force which occasioned minor jointing throughout the region. The evidence is twofold: first, the gabbro is cut by well-defined joint planes, which are of such a nature as could hardly be due to contraction through cooling; and second, small offsets in the veins are occasionally met with in the mines. If such a force operated, it was a comparatively unimportant event in the history of the region.

It is possible that there was jointing as the results of several earth movements subsequent to the folding.

INTRODUCTION OF DIABASE DIKES.

The first event of known age is the introduction of diabase dikes. These were introduced in Triassic time; for the same rock is found elsewhere cutting both slate and Triassic sandstone. The length of the interval between the period of ore deposition and the coming to place of the diabase is not known, but is undoubtedly large. The diabase cuts the gabbro presumably along joint planes; in the other formations it also appears to have been introduced along joint directions.

WEATHERING AND EROSION.

Although operative to a greater or less degree since the region was first elevated by folding, the forces of weathering and erosion have been especially active from the introduction of the diabase to the present. This period, then, is dominantly one of plantation and rock decay; to such an extent, indeed, that the entire region has been reduced once to an approximate base-level, and although rejuvenated by uplift, is again approaching that state. The result of this very last chapter in the geologic history has been to blur over and destroy the records of the previous chapters; yet enough remains to construct a sequence of events, which represents in fair measure the geologic development of a unique region.

SUMMARY OF GEOLOGIC HISTORY.

	1. Building up of the volcano-sedimentary series. Alternations of volcanic activity and periods of quiescence.
Pre-Cambrian (?).	2. Consolidation of the series.
	3. Operation of a compressive force, throwing the whole formation into folds, and inducing schistosity, jointing, and probable faulting.
	4. Approach of a mass of igneous rock, announced by the insinuation of gabbro dikes into the region.
Paleozoic (?).	5. Passage of solutions, depositing iron ores and silica, and forming quartz veins and mineralized zones.
	6. Possible second period of earth movements, inducing some jointing.
Triassic.	7. Introduction of diabase dikes.
Post-Triassic.	8. Period of weathering and erosion.

THICKNESS AND AGE OF THE SLATE SERIES.

Thickness.—Nothing definite can be said as to the thickness of the slate series. From the cross-sections, however, it appears probable that the series is about from 2 to 4 miles thick. This estimate is given by no means as a final figure, but with the hope that future work in the same province may turn it into something more definite, corroborative or otherwise.

Age.—Again, nothing final can be said about the age of the slate series. It is generally considered as Pre-Cambrian. Volcanic rocks of a somewhat similar nature in the South Mountain region of Pennsylvania occur beneath Cambrian sandstone.[1] As there is no evidence to the contrary, the present series is provisionally correlated with the Pre-Cambrian.

[1]Williams, George H. The volcanic rocks of South Mountain in Pennsylvania and Maryland Am. Jour. Sci., v. 44 (1892): 493–494.

CHAPTER VI.

ORES AND MINES OF THE DISTRICT.

HISTORICAL.

The history of the mining development in Davidson County is largely a record of attempts to successfully treat the ores. In the earliest history of each mine, the surface ores, which required but little skill for their winning, were mined by individuals; but the finding of complex sulphides at depth in each case necessitated the formation of a company and installation of machinery to successfully meet the changed conditions.

It cannot be ascertained when the earliest prospecting was done in this locality, but it is probable that during the first 25 years of the 19th century some gold was obtained. In 1824 Olmsted[1] mentioned Davidson County as a part of the gold country. About 1830 there was some prospecting carried on near the present Peters mine. In 1838 the Silver Hill mine was discovered and soon this mine was in active operation, although much difficulty was encountered in the attempts to treat the complex mixture of galena and sphalerite, which was met with. Between 1838 and 1862 active mining was rather extensively carried on in many parts of the county, and attention was directed not only to gold, but to silver, lead, zinc, and to a less extent to copper. During this period, the district, and especially the Silver Hill Mine, attained some prominence as a mining center. The Civil War of 1861-65 occasioned a cessation of activity, but work was resumed at several of the mines shortly after. Between 1875 and 1885 there was a second period of activity in production and exploitation of new properties; but from the latter date to 1909 the production has been small.

PRODUCTION.

It is an impossibility to estimate with accuracy the total production of any mine or of the district as a whole. Between 1882 and 1906, according to the reports of the Director of the Mint, the production of Davidson County amounted to about $110,000, mostly gold. Previous to 1880, the reports of the Director of the Mint

[1]Olmsted, Denison. Report on the geology of North Carolina. Raleigh (1825–27): 38.

were included in the annual reports of the Secretary of the Treasury, and gave only the production of the State as a whole. The total production of gold and silver for North Carolina up to 1894 was estimated by Hanna[1] to be about $24,000,000, of which nearly $12,000,000 had appeared on the United States records. Excepting the Gold Hill Mine, the Silver Hill Mine is the most extensively worked and deepest mine in the State. It is very probable, therefore, that the production of Davidson County from the beginning amounts to several million dollars, the greater portion of which represents the output of the Silver Hill Mine.

Cost of production.—Little definite information can be given as to the cost of mining. Labor and fuel are low in price, and work can be carried on during the entire year. The water in the mines is not excessive. In the Emmons Mine, "drifts cost from $5 to $6 per foot when driven by hand on contract, the company furnishing powder and tools, and $2.50 per foot when driven by machines, when the company furnishes air and tools only, contractors furnishing power, etc. Winzes cost $5 per foot under the same conditions."[2]

PRESENT STATE AND IMPORTANCE OF THE DISTRICT.

While none of the mines are being worked in 1909, the district has not been abandoned. Each of the mining properties is looked after by a superintendent, who lives upon the grounds, and the equipment of at least two of the mines, the Emmons and Peters, is in first-class condition, so that work could be started on short notice with little or no initial outlay. The properties are owned by northern capital, chiefly New York and Baltimore companies, one of which has had a representative in the county for the past few years. The Silver Hill Mine was sold in 1908, and the Emmons, Peters, and Conrad Hill mines are reported to soon begin work.

It seems probable, therefore, that with the return of stable financial conditions, some work will again be carried on in the region.

DESCRIPTION OF THE MINES AND PROSPECTS.

Seven mines and numerous smaller workings, some of which are locally called mines, represent the mining development in the Cid

[1]Nitze, H. B. C., and Hanna, G. B. Gold deposits of North Carolina. N. C. Geol. Survey, Bull. 3 (1896): 17.

[2]Steel, A. A., and Pratt, J. H. Recent changes in gold mining in North Carolina. (In Mineral Industry in North Carolina for 1906:41.)

district. These are pretty well confined to the northwest and northeast borders of the area mapped; though prospecting on a small scale has been carried on in all parts of the district. The largest and best known mine is the Silver Hill. Less well known are the Conrad Hill, Emmons, Silver Valley, Peters, Cid, and Ward mines. The location of these mines is shown on the map. (Plate IV.)

In 1908, when the field work for this report was carried on, none of the mines were in operation. The following descriptions are consequently in much less detail than if the underground workings had been accessible. The descriptions are based upon surface observations; laboratory studies of the best specimens of ore that could be obtained from the dumps; accounts given by reliable men, conversant with the past development of the mines, many of whom had direct supervision of the work; and compilations from all available articles descriptive of the mines. The endeavor has been to collect data from all possible sources, to select only that which appeared authentic, and to combine the whole into an account which will represent all that is now known of the mines.

TYPES OF DEPOSITS.

The mines and prospects of the district for convenience of description may be divided into three classes or types of deposits. These are designated as follows:

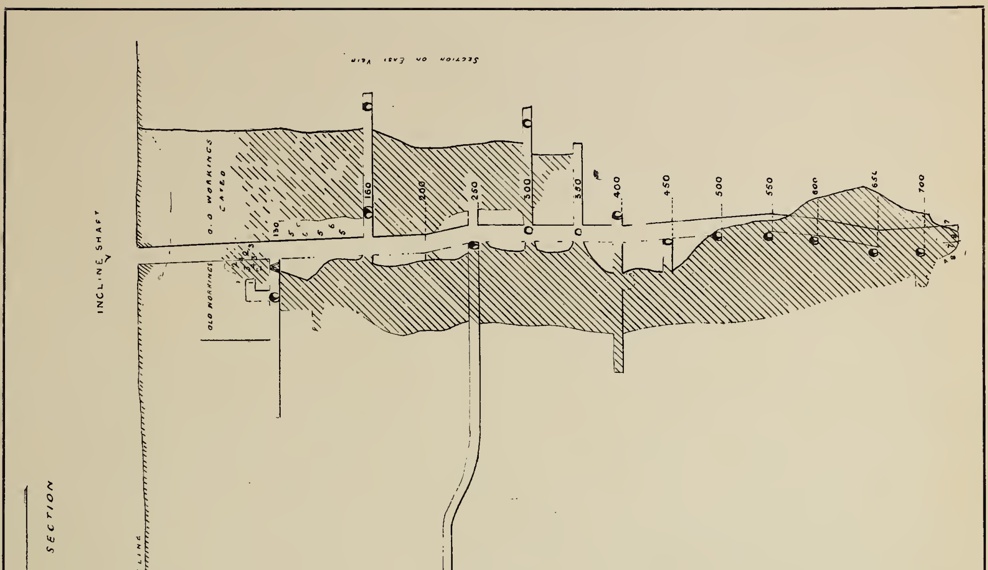
1. Silver Hill type, in which the ores consist of a complex mixture of galena and sphalerite, together with pyrite and chalcopyrite, the whole carrying silver and gold, in a highly altered country rock with little or no quartzose gangue.
2. The Conrad Hill type, in which the ores consist of auriferous pyrite and chalcopyrite in a gangue of quartz, hematite, and siderite.
3. The Emmons type, in which the ores consist of auriferous pyrite and chalcopyrite in a quartzose gangue, or as narrow stringers in the schists with little or no gangue. This type corresponds to the Gold Hill type of deposit, described by Laney.[1]

THE SILVER HILL TYPE.

The Silver Hill Mine.

Location.—The Silver Hill Mine is situated about 10 miles southeast of Lexington and about 4½ miles northeast of Fairmont, near

[1] Laney, F. B. The Gold Hill mining district. N. C. Geological and Economic Survey, Bull. 21, p. 83, 1910.



LONGITUDINAL SECTION OF NORTH AND INCLINED SHAFTS OF SILVER HILL MINE.

the source of Buddle Branch. It occupies the top of a low, well-rounded hill, which rises gently from a country of subdued relief.

History.—This mine, for a long while known as the Washington silver mine, and at one time in its earliest history called King's mine, was discovered, according to the most authentic accounts, in 1838. In the spring of that year, "the owner (Byerly) of a small tract was led to examine a spot at the top of a hill * * * in the hope of finding gold. He found the carbonate of lead and then sold his possessions. Mr. Roswell King, who became the purchaser, sunk a shaft and fell in with the ores of the other metals, silver, copper, zinc, during the summer of the same year, and in the following winter the Washington Mining Company was incorporated."[1] The surface ores, chiefly lead carbonate with disseminated plates of native silver, were easily reduced and yielded handsome returns. This was of short duration. Sulphides were soon reached and presented great difficulties of extraction. Then began a long period of experimentation with the view of successfully separating the precious metals from their intimate associates, galena and sphalerite; during which time method after method was adopted, only to be subsequently abandoned, often unfortunately after the installation of an extensive and costly plant.

In the first attempts to separate the metals, only silver and gold were saved. Then it was thought that the lead also might be saved by the elimination of zinc by volatilization. A difficulty arose in the presence of so much zinc, the vapors of which carried off mechanically some of the lead, silver, and gold, which was lost. Later, in about 1850, a method was in use for separating the zinc by oxidation. This process is rather completely described in the *Mining Magazine* for 1853,[2] and is something as follows: The ore is broken into coarse fragments and roasted in heaps in the open air, by means of wood or wood charcoal. The zinc is thus converted to the oxide, which is washed away by water at the stamp mill, while the mass is crushed to a fine powder. A portion not completely oxidized is returned to the roasting piles. The residue, free from zinc, is brought to the smelting furnace, called a "high furnace," and there smelted with fluxes by charcoal. About one ton of lead is obtained in 12 hours. The lead is transferred to a refining furnace and concentrated. The rich lead is then taken out and refined in cupels.

[1] Mitchell, Elisha. Elements of geology; with an outline of the geology of North Carolina. 1842

[2] Gold and silver produced by the mines of America from 1492–1848. Min. Mag., Ser. I, v. 1 (1853): 365–373.

This was evidently found unsuitable, for in 1856 a modification was described[1] which depended "upon a mechanical separation of the zinc from the silver, prior to its introduction into the smelting furnace. This is effected by Bradford's Separators, which, after the pulverization of the sulphurets, is detached from the galena by a simple shaking movement of a plate of copper, aided by water, over which the metals are passing."

The mine was worked almost continuously by a Philadelphia company until 1852, when the workings were allowed to fill with water. By this time the deepest shaft had been sunk 15 feet below the 200-foot level. In 1844 very rich silver ores and beautiful arborescent and dendritic masses of the native metal were obtained from between the 60- and 100-foot levels. The production in 1844 is stated to have been $24,009.01 in silver and $7,253.69 in gold. The mine was again in operation in 1854 and work was continued until 1861. A portion of the time between 1861 and 1864 the mine was operated by the Confederate Government for lead alone. As much zinc as possible was separated by concentration at the mine, and the ore was shipped to Petersburg, Virginia, where it was smelted and the lead used for bullets. Succeeding the Civil War the mine was probably at no time long idle until 1882, since when little work has been done.

In 1872 the deepest shaft had reached the depth of 650 feet. At this time the ore was separated by buddles after crushing, and the buddled ore roasted and shipped to New York for the manufacture of so-called Bartlett's white lead.[2] For this purpose much of the discarded ore upon the dumps was also utilized. It is probable that the buddles had been more or less in use during the previous 20 years. This method is reported as probably the most successful which has been used. In 1878 a large body of carbonate ore was discovered and a part shipped during the two following years. The mine was quite active during this period, the efforts being confined largely above the 250-foot level. But with the working out of the oxidized ores, difficulties were again encountered in treating the complex mixture of sulphides. This, together with some litigation over the title, caused a cessation of work, and in 1882 the workings were allowed to fill with water.

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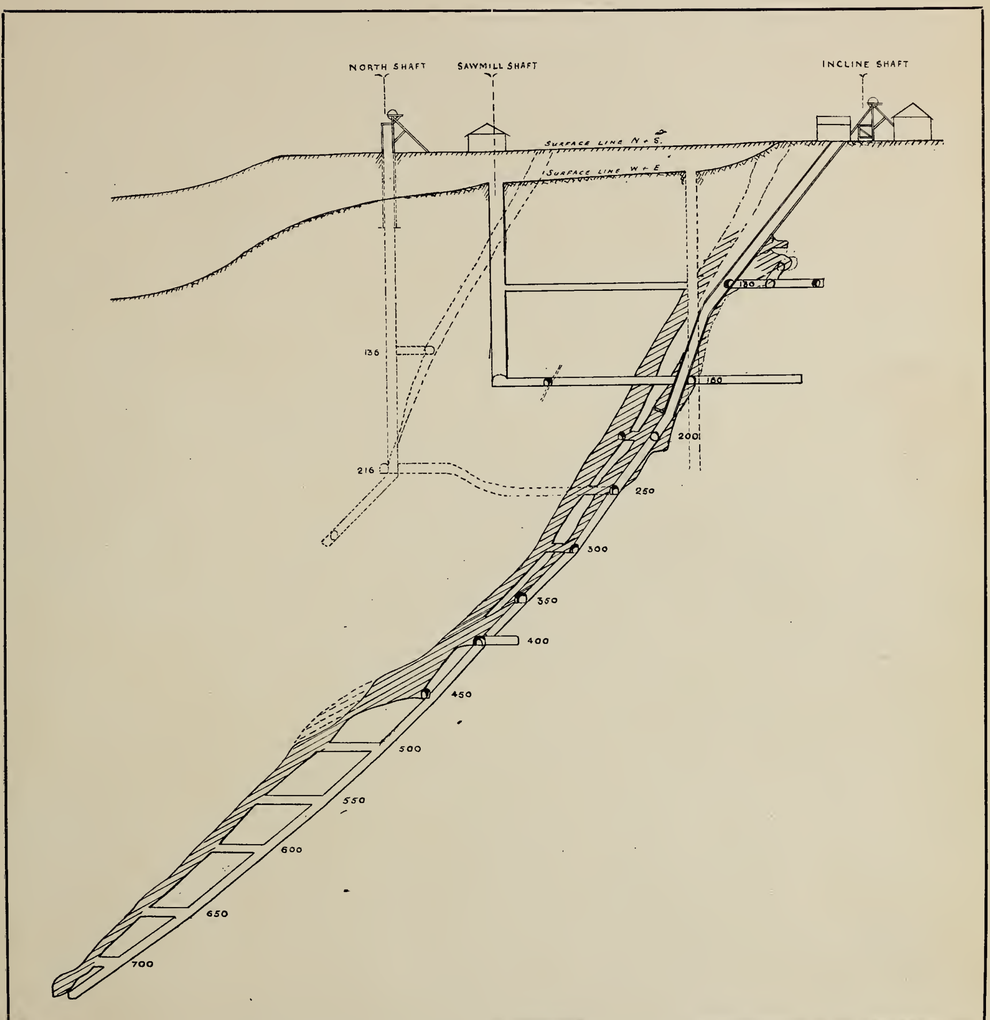
[1]Emmons, Ebenezer. Geological report of the midland counties of North Carolina. Raleigh (1856): 193.

[2]Genth, F. A. On the mineral resources of North Carolina. Frank. Inst. Jour., v. 63 (1872): 48–61.



CROSS-SECTION OF NORTH, SAW-MILL AND INCLINED SHAFTS OF SILVER HILL MINE.

In 1898 the mine was unwatered, the incline shaft was enlarged and re-timbered fully to the 250-foot level and repaired to the bottom. Work was carried on chiefly below the 200-foot level until 1900 by the West Prussian Mining Company and some shipments of argentiferous galena and blende were made. In widening the shaft above the 200-foot level considerable native silver was found. Again the inability to successfully concentrate the ores seems to have put an end to the working. A careful survey was made of the underground workings by Mr. E. Hopkins, the engineer in charge, and the results of his survey are reproduced in Plates XVI, XVII, and XVIII.

In August, 1908, the property was reported to have been purchased by a New York company.

Surface features.—The country rock is predominantly a sericite schist, striking about N. 35° E., and dipping steeply to the northwest. The two principal veins, known as the "East" and the "West," are parallel and 28 feet apart on the surface, though their outcrops can not now be traced. The schists in the vicinity of the mine are brilliantly colored upon weathered surface, indicative of a mineralized zone. An outcrop of andesitic breccia is found within a few hundred feet of the main shaft, and belts of the same rock occur a mile to the south and to the southeast. The sericite schists represent the mashed phases of acid tuffs. Upon the dumps are found many specimens showing clearly their fragmental nature.

Underground development.—The mine has been developed chiefly by an inclined shaft in the east vein, which follows the vein for about 725 feet to a vertical depth of 570 feet. A vertical shaft, known as the Sawmill, Engine, or Whim shaft, connects with the inclined shaft at the 160-foot level; and another, known as the North shaft, connects at the 250-foot level. Both veins have been worked from these shafts by means of connecting cross-cuts. Down to 310 feet the levels in the east vein were driven each 50 feet on the incline and extended both northeast and southwest; below 310 feet, 50 to 75 feet to the north only, since the shoot of ore appeared to be pitching to the northeast. The stopes extended 25 to 50 feet from the shaft along the levels, both veins being worked alike.

The development up to 1898 and the amount of ore stoped is shown in Plates XVI, XVII, XVIII.

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The development up to 1898 and the amount of ore stoped is shown in Plates XVI, XVII, XVIII.

"The mine has been more or less prospected for about 700 feet of its entire length, but the vein formation extends a much greater distance. * * * Two small veins are found from 100 to 175 feet in depth; the Little East vein, a few feet east of the main East vein, and nearly parallel to it; and the Little West vein, some 50 feet west of the main vein, and inclining toward it. Small outlying lenticles were encountered occasionally in driving into the 'country,' and the main vein was occasionally divided by 'horses' of schist.

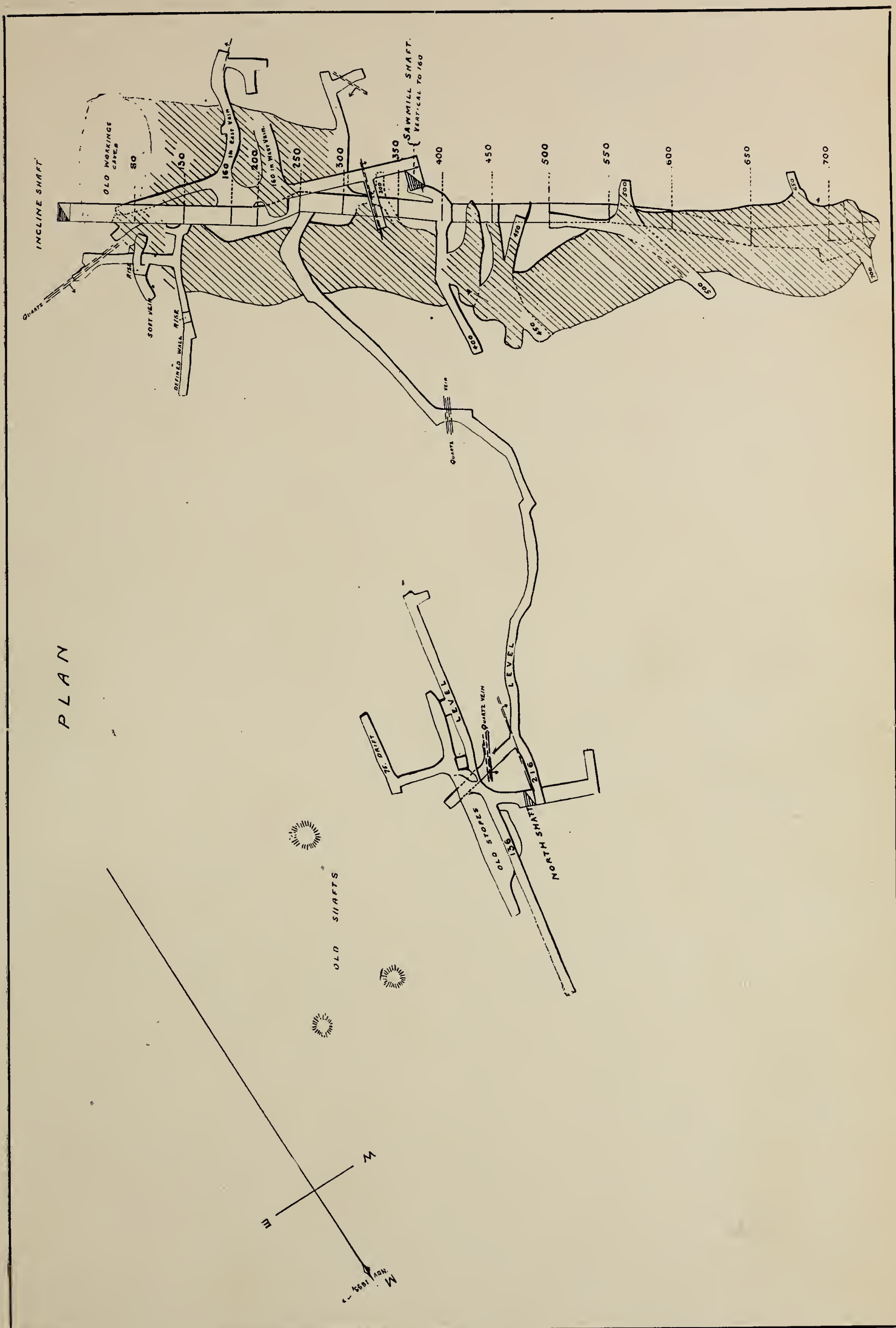
"The veins come together at the 60-foot level just to the southwest of the Engine shaft, where the West vein was richer in silver. At the depth of about 400 feet * * * the two veins united again. * * * At the 60-foot level, and down to the 100-foot level of the West vein, there also occurred a good body of manganese ore, and associated with it most of the cabinet specimens for which this mine was noted. * * * The West vein also expands considerably between 60 and 100 feet; but in the expanded parts it was regularly defined, and often had 'vugs' with rich mine matter. In this zone the ore was changed from oxides to sulphides, with blende predominating over the galenite. Below the 160-foot level the East vein again becomes richer in silver. * * *

"For 160 to 200 feet the vein becomes still more steep. * * * Near the 200-foot level the West vein is 10 to 16 feet thick, and is filled with argentiferous galenite. * * * The East vein is divided by a 'horse' at the 160-foot level. * * * Below the 200-foot level the blende gradually increases, and finally predominates over the galenite. * * * At 170 feet the richest ore was found in a lenticle in the general mass, 2 feet thick. * * *

"Passing to the north along the East vein are the Symond's shafts. Sulphide ores were encountered here near the surface. * * * Symond's east shaft was sunk 110 feet, and the west shaft 210 feet. * * * A level was driven from near the bottom of Symond's west shaft, running angling back to the Engine shaft in the East vein."[1]

Ore.—The ore is predominantly a complex mixture of sulphides, chiefly galena and sphalerite, with some chalcopyrite and pyrite; the whole carrying silver and a little gold. In the upper workings large bodies of carbonate ores, carrying high gold and silver values, have been encountered. From specimens on the dump, there appears to be little quartz associated with the ore. The gangue is chiefly the

[1]Nitze, H. B. C., and Hanna, G. B. Gold deposits of North Carolina. N. C. Geol. Survey, Bull. 3 (1896): 62–65.



PLAN OF SILVER HILL MINE, DAVIDSON COUNTY, N. C.

[illegible]

country rock; and some of the ore has a banded appearance, resembling the structure of the schists, as if the ore had replaced the rock.

Upon the dump are found two interesting rock types, whose underground relations are not known. One is a grayish-green, tough rock composed of interlocking and radiating fibers of actinolite; and probably is a dike rock. The other is a dull, grayish-green, rather soft rock, which mashes to a white powder. By a hand lens it is seen to be made up of a green mineral and feldspar. The microscope shows it to be composed of numerous shreds of biotite in a fine granular aggregate of feldspar, with some quartz. Garnets are abundantly present. This rock is suggestive of contact metamorphism.

A dense, siliceous "hornstone" is found on the dump, and is often mineralized. This represents a silicified tuff or devitrified rhyolite, and is probably a part of the wall rock.

Assays of ore.—The following is an average of 200 assays and will give some idea of the run of the ore:[1]

Galena	21.9%
Pyrite	17.1%
Sphalerite	59.2%
Ag. and Au.	00.025%
Chalcopyrite	01.8%
	100.025%

Below is given the results of a sampling made of the mine in 1898 by E. Hopkins, Engineer for the West Prussian Mining Company. The numbers of the assays correspond to numbers in Plate XVI.

ASSAYS OF ORE FROM THE SILVER HILL MINE.

No.	Description of Ore.	Gold.	Silver.	Lead, per cent.	Zinc, per cent.	Copper, per cent.
1	Mixed sulphides	$ 12.00	$ 17.94	15	28	1
2	Silver rock	5.00	58.20			
3	Pyritic gold ore	191.00	44.40	10		
4	Pyritic gold ore	507.00	120.00	10		
5	Mixed sulphides	8.02	18.40	17.69	35	
6	Mixed sulphides	6.12	57.60	16.5		
7	Ore fr. 700 ft. level	4.67	3.64	19.47	37	
8	Ore fr. 700 ft. level	trace	4.08	17.3	39	0.3
9	Ore fr. N. shaft	trace	6.60	13.0	40	estimated

Equipment.—The mine has practically no equipment at present. The buildings, confined to a shaft house and a few small offices, are dilapidated. All the machinery has been either discarded or sold.

[1]Nitze, H. B. C., and Hanna, G. B. Gold deposits of North Carolina. N. C. Geol. Survey, Bull. 3 (1896): p. 66.

Silver Valley Mine.

Location.—The Silver Valley Mine is situated 5 miles northeast of the Silver Hill Mine, and about 12 miles southeast from Lexington. It occupies the western side of a small valley through which Flat Swamp Creek flows.

History.[1]—This mine, for a short time known as the Spring Valley Mine, was discovered in June, 1880. Development work was immediately started and by the end of the same year a 10-stamp mill had been completed. The following year work was actively prosecuted, 90 men being employed; and the lower grade ore was stamped and passed through 9 buddles. This treatment of the ore, which is a complex mixture of sulphides similar to the Silver Hill ore, evidently proved unsatisfactory, for in 1883 the shaft was allowed to fill with water. Up to December, 1882, 1,000 tons of ore and concentrates were shipped. In 1884 no work was attempted, except to test two "double Rittenger tables," which had been installed the previous year for concentrating the ore and separating the blende from galena. These also were found unsuitable, and no further work was done until 1887. At that time the mine was reopened to supply the newly erected smelting works near Thomasville. This plant was organized by the North Carolina Smelting Company especially to treat the silver bearing ores of the Silver Valley Mine; but it was also hoped that the plant would furnish a near market for concentration of ores from a number of the smaller mines of the Appalachian region. A tramway was constructed from the Silver Valley Mine to the smelting works. A small amount of the ore was shipped from the State for experimental purposes.

The new smelting works did not prove a great success. In 1890 an increase in the silver production of the State was reported, "due to the starting up of the North Carolina Smelting Works at Thomasville." But evidently no satisfactory method of treating the ore was decided upon; for 1891 was taken up almost entirely in making tests on the Silver Valley ore, and in 1892 the plant passed into the hands of the New Jersey Smelting Company. After thorough overhauling under the new management, the plant was again in operation in 1893, when several hundred tons of ore from Silver Valley were used in admixture with ores from various parts of North Carolina. The treatment was said to be successful. The

[1]Largely from the reports of the Director of the Mint, 1880–1894.

lead and zinc were separated as oxides and the precious metals went on the market as matte. The following year the operations were greatly abridged.

In 1895 a "successful process was introduced by Mr. Nininger, of Newark, N. J. It consists of a down-draught jacket furnace, through which the fumes of lead and zinc are carried downward in condensers, where they are met by a spray of water, the liquor being led to vats where the lead oxide is deposited, while the zinc remains in solution and is subsequently precipitated as zinc oxide. The matte, carrying copper, gold, and most of the silver, is tapped from the well of the furnace and cast into pigs." [1] Shortly after 1895 all work ceased.

No work has been done at the mine since 1893, except unwatering and cleaning out in 1903.

Surface features.—The mine is situated in a complex formation represented by outcrops of sericite schist, slate, acid volcanic breccia, andesite, andesitic breccia, and acid fine tuff. Nearly every type of rock in the entire district is found within a half mile. In the immediate vicinity perhaps the most abundant outcrops are light colored schists, from their positions and relations regarded as mashed acid tuffs or breccias. The main vein is situated on the western bank of Flat Swamp Creek, and is entered by a vertical and an inclined or underlay shaft. Some work has been done on a quartz vein alongside a small branch flowing into Flat Swamp Creek and entered by a shaft 230 yards northeast of the main shaft. Some gold is said to have been panned for several hundred yards up the branch, and along its length are found old diggings and an abandoned shaft at which a little work was once done.

Underground development.[2]—The extent of development in the main vein up to 1883 is shown in the accompanying diagram (Plate XIX). The New West or Bashor shaft is now 210 feet deep. At the 150-foot level a drift extends south 200 feet and north 80 to 100 feet. At 150 feet a cross-cut has been driven west 100 feet and east 20 feet. The bottom level runs north about 75 feet. The vein has a trend of about N. 35° E. and dips 45° to the northwest; in width it varies from 5 to 12 feet. It consists of bands of ore, quartz and country rock. The foot-wall is a brittle, fine-grained, siliceous

[1]Nitze, H. B. C., and Wilkins, H. A. J. Gold mining in North Carolina and adjacent South Appalachian regions. N. C. Geol. Survey, Bull. 10 (1897): p. 40.

[2]From statements by Mr. Alex. Hedrick, Superintendent in 1908, and from Nitze and Hanna. Gold deposits of North Carolina. N. C. Geol. Survey, Bull. 3 (1896): 66–68.

rock, which is either a fine tuff or a devitrified rhyolite. The hanging wall is a schist, probably the mashed tuff or breccia, into which the vein grades without a definite, clear-cut boundary. The ore seams are from 3 to 18 inches thick. The Branch shaft, sunk on the small quartz vein to the northwest, is 80 feet deep, with a level running northeast about 40 feet. The character of the ore here is about the same as in the main shaft.

Ore.—The ore of the Silver Valley Mine is a complex mixture of galena, sphalerite, chalcopyrite and pyrite, carrying gold and silver. It is similar to the Silver Hill ore. From specimens on the dump the ore occurs both in quartz and in the country rock. Quartz is apparently not an abundant gangue.

The following table of assays will give some idea of the run of the ore:

ASSAYS OF ORE FROM THE SILVER VALLEY MINE.[1]

	36	37	38
Gold, per ton	trace	$ 4.13	trace
Silver, per ton	$ 17.19	176.49	$ 38.14
Lead, per cent	15.54	55.25	38.80
Zinc, per cent	31.43	11.24	32.00

	39 Poor concen.	40 Good conc.	41 2d conc. fr. poor ore	42 2d conc. fr. solid ore.
Gold, per ton	$ 4.13	$ 4.13	$ 1.03	$ 1.65
Silver, per ton	23.01	44.74	13.08	14.34
Lead, per cent	11.18	47.62	9.63	8.13
Zinc, per cent	27.70	12.68	27.84	33.54

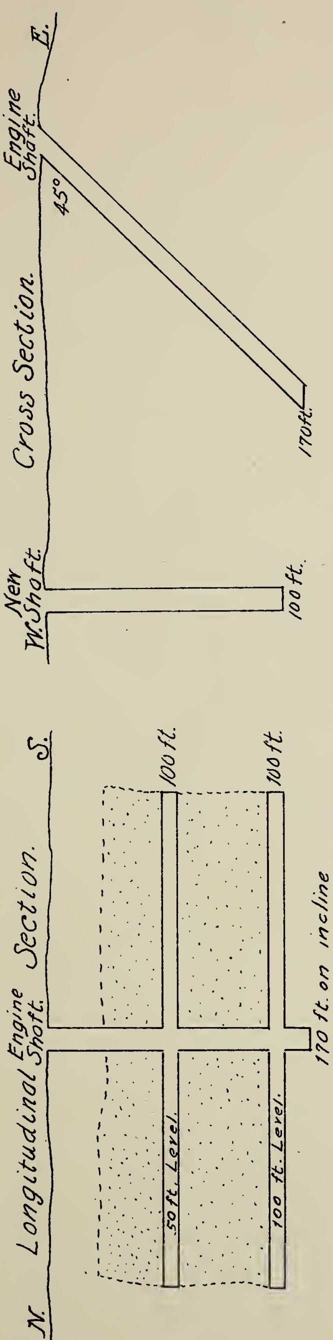
Assay No. 36 more clearly represents the common run of the slightly cobbed ore, and No. 38 the more massive ore. No. 37 is exceptional. The gold is not uniformly diffused; it tends to follow the pyrite.

Equipment.—Most of the equipment of the mine has been sold. The shaft house is still standing, but the mill house is not in good condition.

Welborn Mine.

Location.—The Welborn or Smith mine is situated 2 miles west of Silver Hill and is not included within the confines of the geologic map.

[1]Nitze and Hanna. Gold deposits of North Carolina. N. C. Geological Survey, Bull. 3.



SILVER VALLEY MINE, DAVIDSON COUNTY.

Dotted spaces show the extent of the mining operations up to January, 1883. Scale: 1 inch = 75 feet.

History and description.—The Smith or No. 1 shaft was sunk in 1882-83 to the depth of about 50 feet and a concentrating plant was installed. In 1883 several hundred tons of ore had accumulated on the dumps and an attempt was made to smelt it. The reduction process proved unsatisfactory and the mine was closed in June, 1883. The mine is reported to have produced 6-8 tons of ore per day, assaying high in silver and gold.[1] During the course of the work, another shaft, the Miller shaft, was sunk about one-fourth mile southwest of the No. 1 shaft.

The country rock is a dark blue to green, badly mashed schist. Some facies are clearly fragmentary, this feature appearing especially well upon the weathered surface. The rock doubtless represents an andesitic tuff or breccia. The vein consists of narrow, lens-like intercalations of quartz in the country rock, and having in common with it a strike of N. 25° to 30° E. and a dip of 20° to the northwest. The ore is a complex mixture of galena and sphalerite, similar to the Silver Hill ore.

The mine has been abandoned and is overgrown with bushes and underbrush. No ore can be found on the old dump. A few hundred yards away is the remains of an old furnace and concentrating plant.

Nooe Mine.[1]

The Nooe mine is situated about 3 miles north of Silver Hill, and off the confines of the geologic map. In 1880 a shaft was sunk to the depth of about 60 feet and a "baugh" gold mill was erected, in which the ore was crushed in stone breakers and rollers, roasted, pulverized, and amalgamated in tubs. The plant is stated to have run only about two months. The remains of the mill may still be seen on the property.

The country rock is a dark blue schist, striking N. 35° E. with a vertical dip. It appears to be fragmental in character and probably represents a mashed andesitic tuff. The vein matter averages 3 feet in thickness and consists of quartz stringers, containing lenses of ore, distributed in the country rock. The ore is a mixture of galena, sphalerite, pyrite, with a little gold and chalcopyrite. Sphalerite is the most abundant constituent of the mixture.

The mine is now abandoned.

[1]Reports of the Director of the Mint in 1882: 625.

Ida Mine.[1]

The Ida mine is situated $1\frac{1}{4}$ miles a little east of north from the Silver Hill mine, and in the same belt of sericite schists. A shaft was sunk in 1878 to the east of a large quartz vein which showed upon the surface. A cross-cut was driven into the foot-wall for about 60 feet, but the quartz vein was not encountered. The country rock is a sericite schist, trending N. 20° E., with a dip of 65° to the northwest, and has some pyrite disseminated through it. The shaft is now abandoned and caved.

Sechrist Mine.

The Sechrist mine is situated $1\frac{1}{2}$ miles northeast of the Silver Hill mine in a belt of andesitic breccia. A shaft was sunk on a large outcrop of quartz carrying pyrite and lead, but little or no ore was encountered, and the prospect was consequently abandoned.

Baltimore Mine.[2]

The Baltimore mine is situated about three miles north of Silver Hill, off the boundaries of the geologic map. It was prospected long before 1880. About 1880 it was cleaned out and retimbered 61 feet to the bottom; and a little drifting was done to the north. Stoping previously done to the south had caved and was not disturbed. A few tons of ore were taken out. No work has been done since.

Free-milling brown ore was found to a depth of 60 feet. Below that level pyrite, carrying a little chalcopyrite, galena, and gold was encountered. The shaft goes down on a quartz vein about 3 feet in width.

THE CONRAD HILL TYPE.

Conrad Hill Mine.

Location.—The Conrad Hill mine is situated 6 miles east of Lexington and about 6 miles a little east of north from Silver Hill. Its location is not shown upon the geologic map, but the eastern edge of the map, if extended one mile, would include the mining property. It occupies the top of a well-rounded hill, rising with gentle slopes 100 feet or less above the adjacent valleys; and separated from Three Hat Mountain to the east by a rather prominent valley.

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[1]From information kindly given by Mr. J. A. Shirley of Silver Hill and from the observations of the writer.

[2]Largely from information kindly furnished by Mr. J. F. Peters of Silver Hill.

History.—The Conrad Hill mine was discovered and worked prior to 1853, for J. D. Whitney[1] mentions having visited the mine in that year, at which time two well-timbered shafts, 115 and 100 feet deep, had been sunk. The mine was first worked profitably for gold in the upper parts of the veins, but soon sulphides were reached and copper found to be the most important metal. Little can now be ascertained of work carried on between 1853 and 1880. The mine, however, was probably closed for the greater part of that time. In 1880 it was reopened, and for some years rather extensive operations were carried on. Two stack furnaces were in process of erection, 150 men were employed, and four veins were worked, with the workings extending to the depth of 250 feet. The "Hunt and Douglas process" was successfully applied to the treatment of the ores. "The roasted sulphurets were leached with a ferrous chloride solution, converting the copper to a soluble chloride, from which it was precipitated as metallic cement on scrap iron."[2] Between 1880 and 1882, $125,000 is reported to have been expended chiefly upon equipment.[3] In 1882 the production was larger than for any other mine in the State. In that year the equipment was as follows: 4 5-stamp batteries with necessary concentrating machinery; melting furnace of a capacity of 10 tons per day; roasting shed with a capacity of 100 tons; 4 reverbatory furnaces; plant for the chemical treatment of copper ore, including 8 solution tanks and precipitation vats.[4] With the completion of the stack furnaces the ore was treated by "matte smelting," followed by refining in the reverbatory furnaces. This process was not found economically advantageous; consequently in 1883 the Hunt and Douglas process, with some modifications, was adverted to, and for a time found successful. In the same year the 20-stamp mill was remodeled, and the copper amalgamating plates were in part replaced by "Moore's wave plate amalgamator," said to have been useful in saving gold.[5] The underground work was carried forward and Dodge Hill, an adjoining property, was acquired and prospected. Within the next few years the mine must have closed, for no further mention of it as a producing mine is found in the reports of the Director of the Mint. The mine was unwatered in 1907 and a small amount of ore was gotten out; but nothing was shipped.

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[1]Whitney, J. D. The metallic wealth of the United States * * * 1854: 130.
[2]Nitze and Wilkins. Gold mining in North Carolina and adjacent South Appalachian regions. N. C. Geol. Survey, Bull. 10 (1897): 39.
[3]Balch, W. R. Mines, miners, and mining interests of the United States in 1882. p. 1120.
[4]Report of the Director of the Mint for 1882, p. 625.
[5]*Ibid.* for 1883, p. 648.

Surface features.—The country rock is a light gray to cream-colored, badly mashed, fine-grained acid tuff, with bedding planes not corresponding with the schistosity. The rock might more properly be called a sericite schist. The veins are several in number and occupy the crests of both Conrad Hill and Dodge Hill. Their distribution is shown on the accompanying map (Fig. 4).

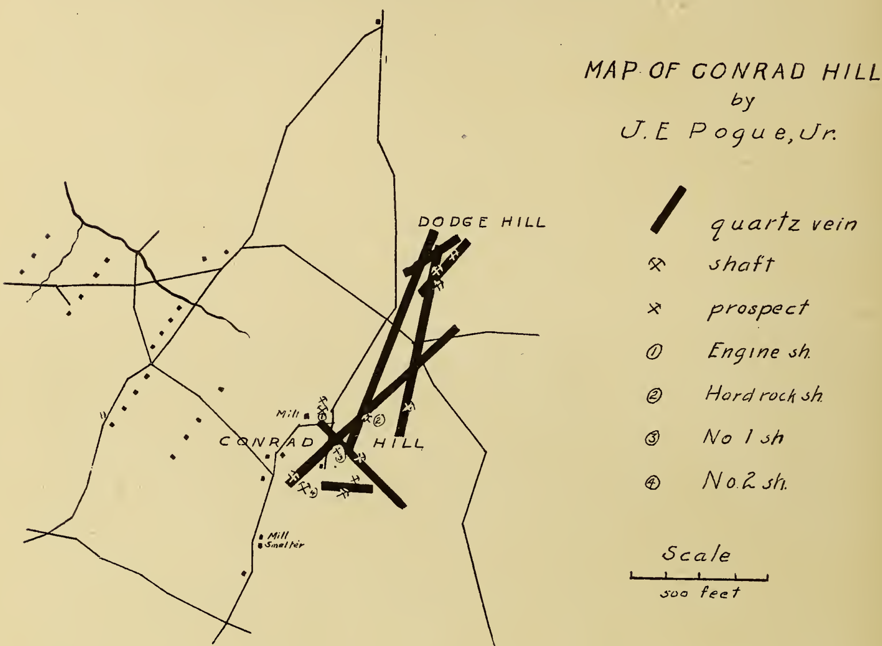


Fig. 4—Map of Conrad Hill Mine, Davidson County, N. C.

The above map gives only in a general way the surface trace of the most prominent veins. An accurate plotting is impossible from the surface features alone; for in many cases instead of being well defined veins, they are great masses of quartz in the mashed and oftentimes shattered country rock. In such instances the trend of the vein is largely a matter of inference from the alignment of the prospect holes. Sometimes the fragments of the country rock are separated from each other by quartz, giving the appearance of a breccia. The veins have been described by Nitze and Hanna[1] as follows: "There are two systems of veins traversing the hill; one

[1]Nitze, H. B. C., and Hanna, G. B. The gold deposits of North Carolina. N. C. Geol. Survey, Bull. 3 (1896): 69.

consists of veins parallel to each other and to the strike of the schists, while in dip they frequently, perhaps it may be said generally, cut the schistosity at a slightly more westerly angle. The second system differs from the first in being entirely independent of each other and of the country rock, in strike and dip."

Underground development.—It is difficult to ascertain the exact amount of underground work done. The following is taken almost verbatim from Nitze and Hanna's report:[1]

There are four shafts sunk in the property, as shown in the map (Fig. 4). In the No. 1 shaft a large body of ore was entered at the depth of 98 feet. At the depth of 105 feet a drift was run some 40 feet north and 90 feet south along and in this body of ore, exposing a thickness of 5 to 10 feet, all of which is stated to contain gold in paying quantities. In the lowest part of this mass of ore, the richer portion, about 4 feet wide, separated from the remainder of the vein by a well-defined line of demarcation, will assay high up to $300 per ton. Just south of the shaft a cut has been made from the drift, across this body of ore, measuring some 37 feet, to the foot-wall, giving a thickness of about 20 feet. A large part of this thickness is composed of crushed country rock, filled with stringers of quartz. A sample taken across this section, including country rock, quartz, and everything representing the whole body of the vein, yielded $22.73 per ton.

In the No. 2 shaft two veins intersect at a depth of 67 feet. A cross-cut has been driven 67½ feet into the veins, exposing on the southeast side of the drift a course of gold and copper ores varying from 18 to 24 inches in thickness. At a depth of 100 feet a drift has been carried some 50 feet south in a mass of ore assaying $13.39 per ton. Some 40 feet north of this shaft, on the same level, a similar ore course of 12 to 20 inches of 33 per cent copper is exposed toward the upper part of the vein, while a stope driven up and along the middle of it, in brown oxide and iron carbonate, gives, by assay of sample representing a thickness of 3 feet, $17.38 per ton for gold.

The Engine shaft is situated 195 feet west of the No. 1 shaft, and is distant 240 feet from the No. 2 shaft. It was sunk 220 feet vertically, and subsequently to 400 feet. At 163 feet the shaft passes through the main cross vein. Throughout the entire distance a rich course of copper ore is exposed from 3 to 8 feet in thickness,

[1]Nitze, H. B. C., and Hanna, G. B. The gold deposits of North Carolina. N. C. Geol. Survey, Bull 3 (1896): 70–72.

of which 1 to $4\frac{1}{2}$ feet is solid prill (*i. e.*, 33 per cent copper) ore, giving an average of not less than two feet. Samples taken from across the whole face, and assayed by Hanna, give $11.98 gold per ton in addition to their copper value.

Ore.—The ore of the mine is pyrite and chalcopyrite, carrying gold. It is distributed irregularly throughout the veins, but judging from small specimens on the dump, seems to be often concentrated into definite portions of the vein. All the ores are said to carry gold, but to vary greatly in value. The upper workings carry limonite and rarely a little specular hematite. The gangue is quartz, siderite, and in rare instances a little chlorite. This last appears to occur near the walls of the veins, and is not essentially a gangue. Oftentimes there is a definite alteration or banding of quartz and siderite. Again the siderite is distributed irregularly through the quartz. The quartz is often subsequent to the siderite; at times the two are contemporaneous; rarely the quartz appears to be older. About 30 per cent of the gangue is estimated to be siderite.

Equipment.—The mine is equipped as follows: Boiler, hoist, etc.; old stamp mill, with 20 stamps, 10 of which are in fair repair; remains of a smelter; numerous smaller buildings and houses not in good repair.

Peters Mine.

Location.—The Peters Mine is situated 2 miles south of east from the Silver Hill Mine.

History.[1]—The first work at this locality was done about 1830. Only a prospect shaft was sunk at that time and work was on a small scale. A little work was also done before and during the period of 1861-65. In 1901 work was resumed, and a shaft was put down to a depth of 60 feet. In 1902 the present plant, consisting of a shaft house and small mill, was erected, and the shaft deepened to 85 feet. Several levels were run, but little stoping was done. About 200 tons of ore were concentrated at the mill, and the gold separated, which was sent to Charlotte. Work was stopped in 1904.

Surface features.—The country rock is a sericite schist, and part of the belt that extends past Silver Hill to Conrad Hill. Two nearly parallel gabbro dikes with a northeast trend pass only a few hundred yards on either side of the mine. Considerable prospecting has been done on a series of quartz veins which extend in a line

[1]According to Mr. J. F. Peters of Silver Hill.

$1\frac{1}{4}$ miles southwest of the Cross Mine, and form the mineralized zone upon which the two mines are located. This must not be considered a continuous, well-defined vein; but rather, a narrow band of the schist which has been mineralized and silicified, and had introduced into it parallel to the schistosity a large number of quartz veins, lenses, and seams.

Underground development.—The underground workings are shown in the accompanying plan (Fig. 5). The vein, which has a strike of about N. 45° E., varies from 3 to 7 feet in width, with an average of 4 feet. Little stoping has been done. The upper levels down to 60 feet carry free-milling ore.

Ore.—The ore is chalcopyrite, with pyrite, and carries gold. The gangue is quartz and siderite. From specimens on the dump, the chalcopyrite and pyrite occur scattered through the quartz and enclosing fragments of it, as if the quartz had been brecciated previous to the deposition of the ores. Siderite is apparently less abundant than the quartz; seams and bands occur in the quartz and are probably later than the siderite. Talc is sparingly present, and is usually near the walls. The ore is stated to run about $11 in gold per ton; its copper value is not known.

Equipment.—Upon the property is a shaft house, connected by a tramway to a small mill. The shaft house is equipped with a 10-horsepower hoist; 15-horsepower boiler; and an Emerson vacuum pump. The mill contains 2 Tremain stamps; 1 Wilfley table; 12-horsepower engine; 35-horsepower boiler; small Blake crusher, with 8 by 10-inch opening; and a $1\frac{1}{2}$-horsepower engine for running the table. The ore is crushed, stamped, passed over amalgamating plates and on to the concentrating table.

The buildings and machinery are in good condition.

Cross Mine.

Location.—The Cross Mine is situated $1\frac{1}{4}$ miles southwest of the Peters Mine.

History and description.—This mine was discovered a short while before 1860 and prospected during 1860-65. A shaft was sunk to the depth of 50 feet. In 1904 the shaft was deepened to 75 feet, and some exploitation work carried on. Work was stopped the same year.

Oxidized ores carrying free-milling gold are stated to extend to

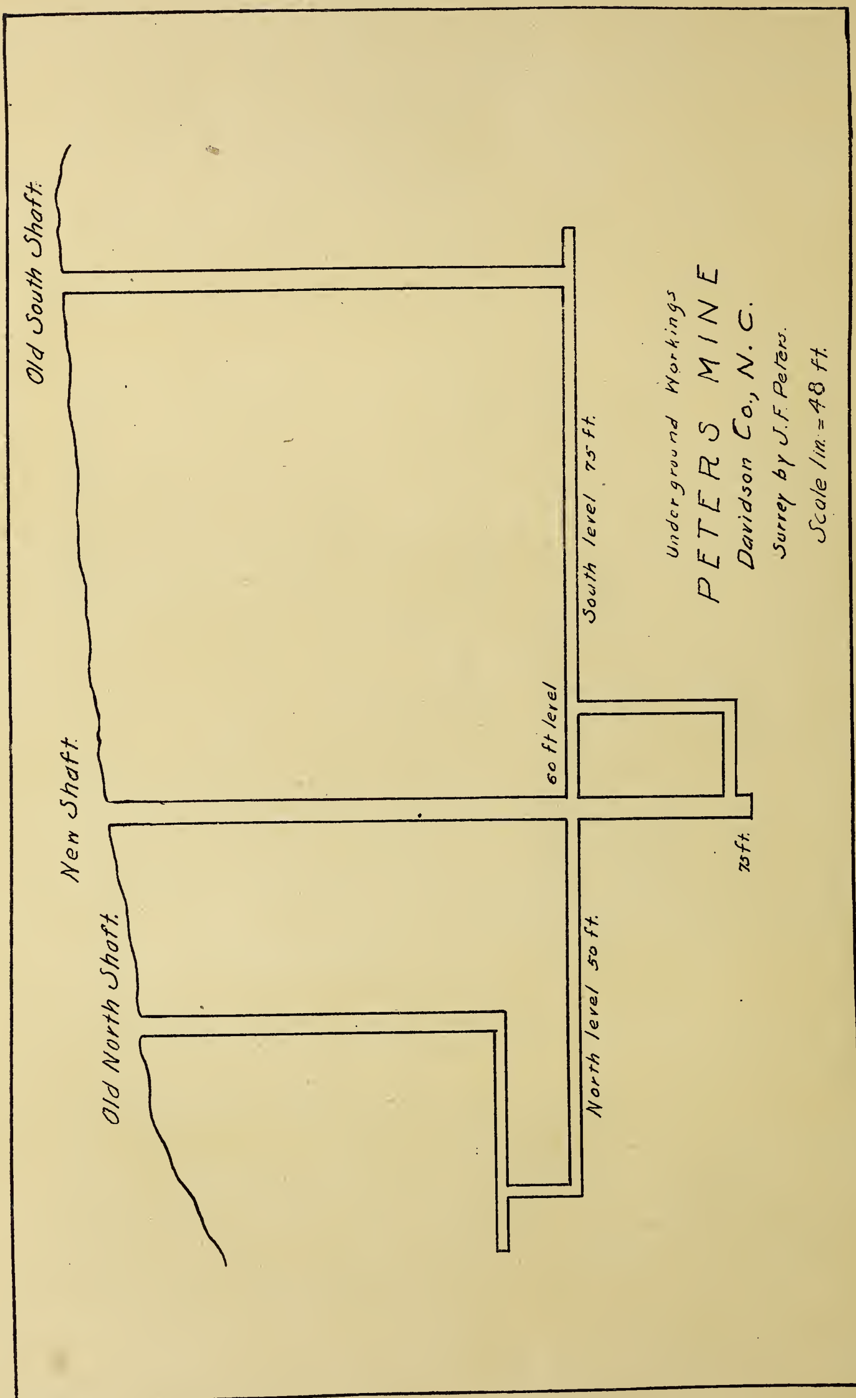


Fig 5—Plan of the underground workings of the Peters Mine, Davidson County, N. C.

the depth of 70 feet and to average about $20 per ton. The shaft goes down on a quartz vein 6 to 18 inches in width.

The equipment consists of a shed and a 1-horse whim.

THE EMMONS TYPE.

Emmons Mine.

Location.—The Emmons Mine is situated 15 miles southeast of Lexington, and about 1 mile south of Cid.

History.—This mine, formerly known as the Davidson Mine, was discovered and worked prior to 1861, but was closed during the Civil War. Shortly after it was reopened and worked several years by a Baltimore company. For treating the ores, the Hunt and Douglas (old) process was used successfully for a long period. In 1885 and 1886 the mine was again operated for a short time. In 1902 development work was carried on, and in the following two years considerable ore was blocked out and a complete concentrating plant installed. The mine has not been actively operated between that time and 1909.

Surface features.—The country rock is a dark greenish-blue, schistose slate, with bedding planes cutting the schistosity at a small angle. The outcrops strike about N. 30° E., with a dip varying from 40° to 70° northwest. Intercalated with the slate in the immediate vicinity of the mine appear outcrops of greenstone schists, which doubtless represent lenses of mashed andesitic tuff. Within a mile of the mine may be found areas of dacite, rhyolite, gabbro, and acid and basic breccias. The veins are not well defined upon the surface, though mineralization is indicated by the highly colored character of some of the outcrops. There are a number of old diggings and shafts in the vicinity; but most of the work has been confined to two veins. The westernmost of these is entered by the Main or Engine shaft and the North or No. 2 shaft. About 100 yards to the east, the second vein is entered by the No. 3 shaft.

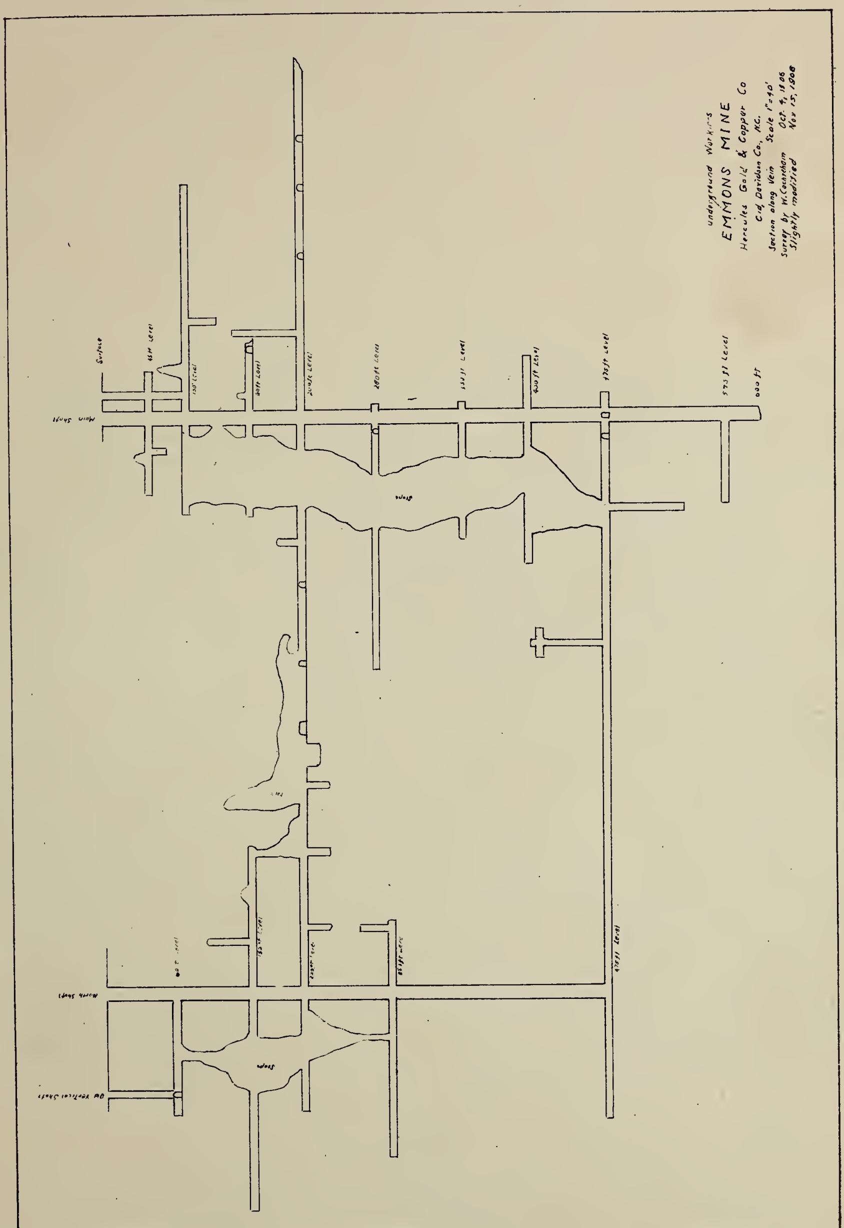
Underground development.—The longitudinal section of the underground workings in the main vein up to November, 1908, is shown in the accompanying plan (Plate XX). "The vein is parallel to the slates and consists of irregular stringers of quartz, often cutting into or surrounding masses of slate. These carry considerable chalcopyrite and pyrite, sometimes mostly one, and sometimes the other. The included and adjoining slates are also mineralized, but there is usually but little chalcopyrite outside the last ribbon of quartz, but sometimes there is very little quartz in the vein. Mr. Cockreham, the superintendent, thinks that the gold follows the quartz. There is no selvage along the walls and at least one of them is very irregular. The ore is generally 2 or 3 feet thick, but in one place it is 12 feet, and the vein is often very narrow. There is no ore south of the main shaft, and the richest shoot is the one that has been continuously stoped, just north of the main shaft. The widest one is just beyond the North or No. 2 shaft, and there is a very long body of ore on the 200-foot level, reaching nearly from shaft to shaft. There is ore in the No. 2 shaft to within 30 feet of its bottom, where it becomes lean and quartzy. Most of the 280-foot level is barren beyond the main shoots, although there is some ore in the upper part of the upraise. On this level the main shoot is not quite so long or so wide, but is a little higher grade. In the breast of this level there is a little ore in quartz. * * * The ore, mined chiefly from the good shoot, runs from 3 to 4 per cent copper."[1] The ore to the north and to the south of the North shaft runs about $1\frac{1}{2}$ to $1\frac{3}{4}$ per cent copper.

The west vein is entered by the No. 3 shaft, which extends to a depth of 170 feet. The 90-foot level runs south for about 25 feet and north about 10 feet. The vein varies from 1 to 4 or 5 feet in width, with an average of about 18 inches, and consists of stringers of quartz in a greenstone schist. Chalcopyrite occurs both with the quartz and in the schists.

Ore and gangue.—The ore in the main vein is chalcopyrite, with some galena, sphalerite, and pyrite, and carries a small gold content. The gangue is siderite, chlorite, and calcite. The ore shoots are said to pitch to the southwest.[2] From ore picked up from the dump, the following features are noted: Quartz stringers are parallel to and cut the schistosity; much of the country rock shows slickensides; pyrite impregnates much of the otherwise barren rock; chalcopyrite occurs both with the quartz and in seams in the schists; calcite is rarely found and is never abundant; chlorite tends to accompany the barren quartz.

The following features were noted from the dump at the No. 3 shaft: Much calcite is present along with the quartz as a gangue; chalcopyrite occurs in the quartz, in the calcite, and in the country

[1]Steel, A. A., and Pratt, J. H. Recent changes in gold mining in North Carolina. (In the mining industry in N. C. for 1906.) N. C. G. S., Ec. Pa., 14: 39–40.
[2]Nitze and Hanna. Gold deposits of North Carolina, p. 60.



UNDERGROUND WORKINGS OF EMMONS MINE, DAVIDSON COUNTY, N. C.

rock; at places seams of calcite traverse the quartz; in one specimen small scales of talc are associated with the calcite; slickensides are abundant, and occasionally pyrite cubes are mashed and drawn out on a slickensided surface; the seams and veins of calcite are both parallel to the schistosity and ramify irregularly through the rock; chlorite is often present in the quartz, but is usually not associated with the ore.

Value of the ore.—A representative car load of concentrates is stated to have given the following smelter returns: 7.7 per cent copper, 1.27 ounces silver per ton, and 0.10 ounces gold per ton; for which was paid $31 per ton, with a charge of $12.80 a ton for smelting and sampling.[1]

Equipment.—The mine is equipped with shaft house, mill, smelter, and a number of smaller buildings, all in good condition. The grounds and plant are well cared for, and work could be resumed at any time on short notice. The Hercules Gold and Copper Company, of New York City, are the present owners of the property, which includes a tract of 400 acres, and the Cid Mine and property of 45 acres.

The mill is equipped with a Blake crusher, feeders, 10-stamp battery, 8 Wilfley tables, classifier, and a Deister table. Its capacity is 50 tons in 24 hours. (See Plate XXI, A and B.)

Cid Mine.

Location.—The Cid Mine is situated 1¼ miles northeast of the Emmons Mine, and in a continuation of the same belt of rock.

History and description.—It was discovered during or before 1882; by December of that year a shaft had been sunk 20 feet.[2] The mine was worked at intervals for a few years. Gold was at first sought, but with little success, and attention was directed to the copper ores. For some reason work was stopped after the sinking of an underlay shaft to the depth of 100 feet. In 1903 the mine was operated on a small scale for a short time.

The country rock is a dark greenish-blue, bedded slate, with lenses of greenstone schist. The vein is not prominent on the surface. The ore is chalcopyrite with pyrite, carrying some silver and a little gold. The mine is at present without shaft house or equipment.

[1]Steel, A. A., and Pratt, J. H. Recent changes in gold mining in North Carolina. (In the mining industry in North Carolina during 1903.) N. C. Geol. Survey, Ec. Paper 14 (1907): 41.
[2]Report of the Director of the Mint for 1882: p. 625.

Ward Mine.[1]

Location.—The Ward Mine is situated 2 miles east of Cid on the crest of a small knoll.

History.[2]—Gold was discovered at this mine shortly before 1853, and surface work was carried on at intervals until about 1882. At this time a shaft was sunk to a depth of about 60 feet, and some exploiting was done. About 1890 the surface was again worked with crude appliances, the shaft deepened about 25 feet, and a cross-cut run east for a short distance. Between 1895 and 1905 further surface work was done; a 20-stamp mill was erected and the shaft retimbered. Only a small quantity of ore was mined and the mine was allowed to fill with water.

Description.—The mine has been worked entirely for gold, which occurs very irregularly distributed through a large mass of quartz. It is with difficulty that the great abundance of quartz which appears upon the surface can be traced into definite veins; it more probably represents a number of intersecting quartz masses and numerous stringers and lenses, with no well defined alignment or walls. There may be one vein running about N. 25° E, and another E. and W. The country rock is a mashed acid tuff, with some slate just east of the shaft. Upon the knoll, in close connection with the quartz, occurs a light gray, massive rock, which may represent a rhyolite or an acid tuff, probably the latter. This is filled with small quartz seams, said to carry good gold values.

"A very large proportion of the gold is crystalline. The pockets containing crystals usually lie in a red, siliceous clay, which has been derived from the rock in contact with a seam of quartz. Some of the pockets have furnished 500 or 600 dollars of crystallized gold."[3]

Gold is said to have been abundantly panned just west of the small rise and along a little stream. There are many pits in this area, indicating rather extensive surface workings. The mine seems to warrant some further surface work; hardly enough development has been done to show up the nature of the vein and its richness.

FEATURES OF THE ORE DEPOSITS.

Certain features of the ore deposits which have a special bearing on origin will here be summarized. It is regretted that lack of

[1]This mine is described at this place for convenience, rather than because it might be strictly classified under the Emmons type of deposit.

[2]According to Mrs. A. J. Gillingham, owner in 1909.

[3]Emmons, Ebenezer. Geological report of the midland counties of North Carolina. Raleigh (1856): 138.

A. Shaft houses at Emmons mine.

B. Mill and smelter at Emmons mine.

direct underground observations necessitates that this account be brief and of a general nature.

LIST OF MINERALS.

A list of the minerals constituting or accompanying the ore deposits is given below, together with the names of the mines in which they are found.

LIST OF MINERALS CONSTITUTING OR ACCOMPANYING THE ORE DEPOSITS.[1]

Ore Minerals:	Anglesite	Silver Hill.
	Argentite	Silver Hill.
	Calamine	Silver Hill.
	Cerussite	Silver Hill.
	Chalcanthite	Silver Hill.
	Chalcopyrite	All the mines.
	Chalcocite	Silver Hill.
	"	Cid.
	Cuprite	Silver Hill.
	Galena	Emmons.
	"	Silver Hill.
	"	Silver Valley.
	"	Welborn.
	"	Nooe.
	"	Ida.
	"	Sechrist.
	"	Baltimore.
	Gold	All the mines.
	Goslarite	Silver Hill.
	Linarite	Silver Hill.
	Malachite	All the mines
	Tenorite	Silver Hill.
	Pyrite	All the mines.
	Pyromorphite	Silver Hill.
	"	Silver Valley.
	Silver (native)	Silver Hill.
	Stolzite	Silver Hill.
	Sphalerite	Emmons.
	"	Silver Hill.
	"	Silver Valley.
	"	Welborn.
	"	Nooe.
	"	Ida.
	"	Sechrist.
	"	Baltimore.
Gangue Minerals:		
	Actinolite	Silver Hill.
	Calcite	Emmons.
	Chlorite	Emmons.
	"	Conrad Hill.
	Hematite	Conrad Hill.
	Orthoclase	Silver Hill.
	Quartz	All the mines.
	Siderite	Conrad Hill.
	"	Silver Valley.
	"	Peters.
	"	Cross.
	Talc	Peters.
	"	Emmons.
	Wavellite	Silver Hill.
	Zoisite	Silver Hill.

Description of Ore Minerals.

Gold occurs in all the deposits; it may be free in the quartz, or closely associated with pyrite, or disseminated through the surface

[1]After Becker, G. F., Gold fields of the Southern Appalachians. U. S. Geol. Survey, 16th Ann. Report, pt. 2 (1895): 28, with additions by Joseph Hyde Pratt.

oxidized ores. Some of the gold found at the Ward Mine is well crystallized. Pyrite is an extremely common ore mineral, and generally carries a gold value; it occurs alone in the schists or in association with chalcopyrite. Galena and sphalerite are found as an intimate mixture in the mines of the Silver Hill type. In such deposits there is also almost invariably a small amount of pyrite and chalcopyrite present; and the whole mass carries a silver and gold value. Galena and sphalerite in small quantities are found in the Emmons Mine. Carbonates of lead and zinc, carrying native silver, have been taken in some quantity from the upper workings of the Silver Hill Mine. The other ore minerals mentioned in the table above are unimportant commercially.

Description of Gangue Minerals.

Quartz is the most abundant gangue mineral, and occurs both in well-defined veins and as lenses and stringers in the schists. It is also found as infiltrated silica in zones which are sometimes mineralized to the extent of being worked as veins. Siderite is an important gangue at the Conrad Hill and Peters mines, where it is nearly as abundant as the quartz. Calcite is abundant in ore from the No. 3 shaft of the Emmons. Limonite, from the oxidation of pyrite, is present in all the surface ores; and in the Conrad Hill Mine hematite is also found in the upper workings. Often the country rock of the mines, usually a sericite or greenstone schist, or a dense, siliceous rock ("hornstone"), is in such intimate association with the vein-stuff as to be essentially a gangue.

DESCRIPTION OF THE VEINS.

The "veins" of the district are apparently of four kinds. These are not well-defined types; nor can they be completely described or established. It is believed, however, from all available evidence and from the careful descriptions given by Becker,[1] Graton,[2] and Laney[3] of veins occurring in other parts of the Appalachian region, that such a division is warranted. The "veins," or more properly, the mineralized zones, are accordingly grouped as follows:

1. *Impregnations,* or stringers of ore in the schists, with little or no quartz. The ore is pyrite, carrying finely disseminated gold, and usually mixed with more or less chalcopyrite. This type is espe-

[1] Gold fields of the Southern Appalachians, pp. 25–43.
[2] A reconnaissance of some gold and tin deposits of the Southern Appalachians, pp. 59–61.
[3] The Gold Hill mining district, pp. 138–141.

cially well developed in the Emmons Mine; though it seems to be present to a less degree in all the mines. It is apparently a subordinate accompaniment of the ore deposition.

2. *Stringer leads,* or lenses and seams of quartz conformable with the schistosity or cutting that structure at small angles. These make up mineralized zones or lodes, which vary from a small number of stringers in much country rock to large lenses of quartz, or true quartz veins, associated with only a few stringers. The whole mass, both quartz and country rock, is often mineralized and worked as a single "vein." Impregnations and stringer leads always occur associated. It is believed that the Emmons "vein" is a combination of the two types. The Conrad Hill and Peters mines are further examples of the same thing; though there is here probably less impregnation than in the case of the Emmons, consequent upon the fact that the quartz veins in the former two mines are prominent and well developed. (See Plate XXII, A.)

3. *Cross veins,* or well-defined quartz veins, which cut across the schistosity at large angles, presumably following joint directions. These are the veins which outcrop most abundantly and prominently upon the surface, and unfortunately are usually barren. The Conrad Hill Mine is the only mine in the district in which these cross veins have been exploited at depth. The descriptions of this mine are not very detailed, but it appears that at the intersections of the cross veins with the "right running veins" (or veins nearly conforming with the schistosity) occur segregations of the ore, and that the other portions of the cross veins have been little worked and are presumably barren or nearly so.

4. *Replacement deposits,* or zones carrying seams and lenses of ore with little or no quartz, and in a country rock extremely metamorphosed or highly silicified. The ore is a mixture of galena and sphalerite, with pyrite and chalcopyrite, the whole carrying silver and gold. This type is represented by the Silver Hill, Silver Valley, and related mines. Such deposits can not definitely be shown to be due to replacement, although they are clearly different from the three first mentioned types. Great solid pieces of ore found on the dump suggest strongly that they have originated from a substitution of the schist by ore matter, so as to preserve the original structure of the rock. These deposits, moreover, are found in highly schistose rocks of a tuffaceous character, such as from their porous

nature would have afforded an easy path for solutions. On the dumps at Silver Hill and Silver Valley is found an abundance of "hornstone," which is likely a silicified tuff, and as such would be indicative of a vigorous circulation. Pieces of this rock contain narrow seams of ore, so that impregnation also went on to a certain extent. The deposits of the Silver Hill type were introduced by waters carrying a high silica content, because the country rock is highly silicified. Yet, while large deposits of metallic compounds were formed, very little free quartz was deposited. This is certainly suggestive of country rock conditions favorable for an interchange of elements so as to form metasomatic deposits, rather than for direct deposition by precipitation; in which case, abundant quartz as a gangue would be expected.

PARAGENESIS OR ORDER OF FORMATION OF THE ORES.

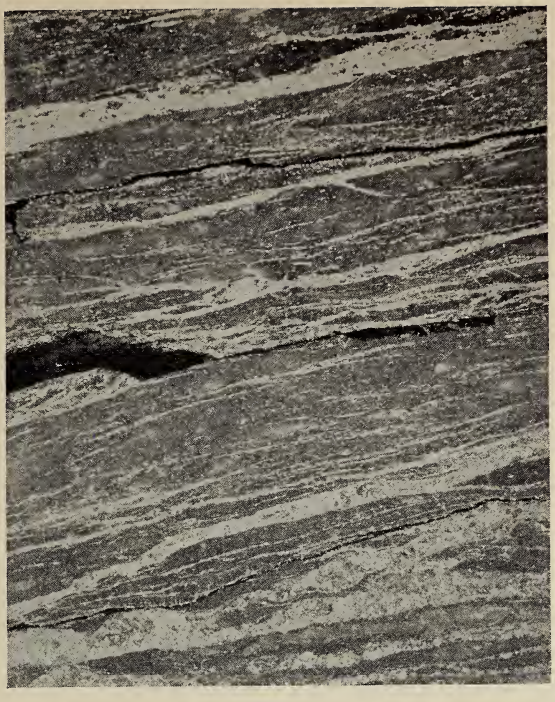
By means of a microscopic study of polished sections of typical ores from the Silver Hill, Silver Valley, and Emmons mines, the following relations of the sulphides have been ascertained. For this work an ordinary microscope, with double-eye piece, was used. The illumination consisted of an acetylene light, the rays from which were filtered through a pale blue cobalt glass and reflected down upon the polished sections. This source of illumination is stated to be practically identical in its effect with daylight.[1] Both polished and etched sections of the ores were studied.

ORE FROM THE SILVER HILL MINE.

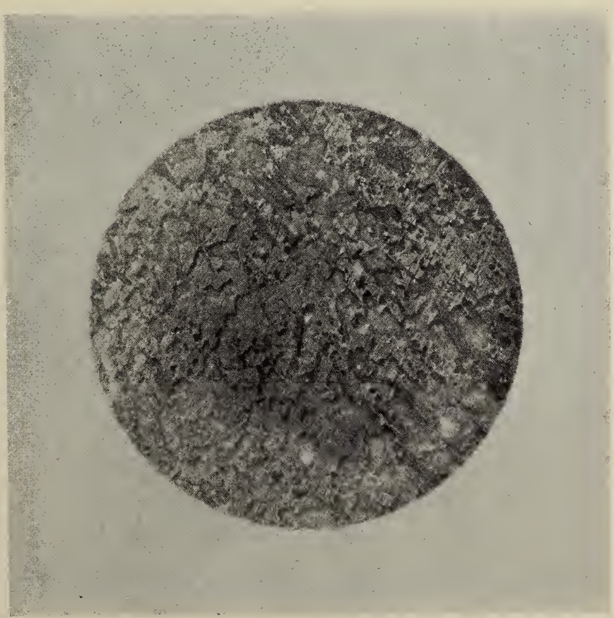
Macroscopic description.—The ore from this mine consists of an intimate mixture of massive galena, sphalerite, and chalcopyrite, with a small amount of pyrite, the whole carrying a silver and gold value. The mixture is so intimate and so fine in texture, that little can be seen with the unaided eye as to the relation of the different minerals to one another. A rough and irregular banding of the minerals is usually seen. A band may be noted in which galena is the prevailing mineral; then one of sphalerite; and this in turn followed by one in which chalcopyrite prevails. There is, so far as noted, no regular succession of these bands, nor do they possess any degree of regularity as to width.

Microscopic description.—The microscope shows the mixture to be

[1]Wright, Fred. Eugene. Artificial daylight for use with the microscope. Am. Jour. Sci., v. 27 (1909): 197.



A. THE "STRINGER LEAD" TYPE OF VEIN, SHOWING STRINGERS AND SEAMS OF QUARTZ AND ORE IN A SCHISTOSE COUNTRY ROCK. THIS IS A PHOTOGRAPH OF A POLISHED SECTION OF THE VEIN IN THE GOLD HILL MINE. THE EMMONS VEIN IS VERY SIMILAR.



B. PHOTOMICROGRAPH OF SILVER HILL ORE; 40 DIAMETERS; SECTION POLISHED AND ETCHED BY CONC. HNO_3. SCRATCHED AREAS ARE CHALCOPYRITE. CLOUDED AREAS ARE GALENA (DEEPLY ETCHED). LONG SHREDS ARE AN AMPHIBOLE, PROBABLY ACTINOLITE. SECTION ALSO CONTAINS A LITTLE SPHALERITE.

even more intimate than the macroscopic examinations indicate. Each mineral is seen to have its own clear-cut and definite boundaries. There is absolutely no gradation of one into the other. The bands in which one mineral predominates over the others are seen to be still an intimate mixture of all the minerals, with only one in greater abundance. The areas between the bands and other irregular areas which occur throughout the specimens consist of a most intimate mixture of very small and irregular grains of all the three sulphides, with now and then a speck of pyrite. These grains have the most irregular form conceivable, and interlock in the most intricate manner. A few fair-sized areas of pyrite occur. When these are placed under the miscroscope, they are seen to possess a spongy appearance and to be literally filled with small and irregular particles of the other sulphides. Around the borders of the pyrite the other minerals are crowded together, and it appears as if the pyrite crystal in growing had pushed aside the greater portion of the other minerals. There were, however, small amounts of these which it could not throw out, and these it engulfed. A few shreds of an amphibole, perhaps actinolite, generally sheaf-shaped or radiating in appearance, were intimately mixed with the sulphides. Some areas of sphalerite are darker in color than others. (See Plate XXII, B.)

From the foregoing examination, it is highly probable that the four sulphides are contemporaneous in origin. The solutions may have varied slightly in composition from time to time, and thus the rough banding may be accounted for. This feature, however, is more indicative of replacement.

ORE FROM THE SILVER VALLEY MINE.

The ore available for study was largely sphalerite, but carried small amounts of chalcopyrite and galena, with very little pyrite. The specimens were not satisfactory for microscopic examination, but everything seemed to indicate a contemporaneous origin for the sphalerite, chalcopyrite, and galena. Nothing definite can be said as to the relation of the pyrite to the other sulphides.

ORE FROM THE EMMONS MINE.

Macroscopic description.—The ore from this mine is a mixture of chalcopyrite and pyrite, carrying a small gold value.

Microscopic description.—The pyrite, for the most part, is apparently older than the chalcopyrite, but at times it seems to be contemporaneous or even younger. The chalcopyrite very often is seen filling cracks and irregular areas in the pyrite, or completely surrounding pieces, apparently rough crystals of pyrite, in such a manner as to strongly suggest a breccia of pyrite in a matrix of chalcopyrite. There is, however, in the sections examined, no very strong evidence as to the respective ages of the two minerals. Each mineral always has its own definite and distinct boundaries. There is no such thing as a cupriferous pyrite; it is a mixture of the two sulphides, chalcopyrite and pyrite. No free gold was visible in any of the ores examined.

GENESIS OF DEPOSITS.

The data presented in the previous portions of this chapter are sufficient to indicate in a general way the most probable mode of origin of the ores of the district. To fully work out their genesis would require detailed underground studies of all the mines, accompanied by extensive analyses and assays of the wall rocks, gangues, and ores; such only as would have been possible, had the mines been open to inspection. Notwithstanding this lack of detailed information, it may be useful to make the best of the information that is available and to construct at least a probable or working hypothesis.

SOLUTIONS.

The ores of the district have been deposited from solutions. The primary ores, or those which have not been altered since their original deposition, are pyrite, chalcopyrite, galena, sphalerite, gold, and argentite or native silver. Of the gangue minerals, only quartz and probably siderite are apparently primary. Such rare occurrences as pyromorphite, stolzite, orthoclase, and wavellite are not considered in the discussion. Of the ore minerals, anglesite, cerussite, chalcocite, malachite, and tenorite are secondary; and of the gangue minerals, actinolite, calcite, chlorite, hematite, limonite were in all likelihood formed after the period of ore deposition. Of the two silver minerals argentite and native silver, the former is probably the primary silver ore, from which the native silver has been derived by reduction; though both may be present among the primary constituents.

The solutions, therefore, probably carried silica in large amounts, together with small quantities of pyrite, chalcopyrite, galena, sphalerite, gold, and argentite; or more strictly, the proper elements, undoubtedly with others also, such as would react to form the six aforementioned compounds.

Becker[1] has shown that silica, gold, pyrite, and the sulphides of copper, zinc, and iron are soluble in waters containing carbonates and sulphides of the alkalies. Galena has been demonstrated to be soluble in water and in solutions of sodium sulphide.[2] Silver is probably soluble in carbonated waters.[3] It seems, therefore, that the primary ores of the district could have been carried in solution and deposited by waters containing alkaline carbonates and sulphides.

SOURCE OF MATERIALS.

The source of the solvent and its burden of dissolved substances can not be definitely established. Either the material, which has been concentrated to form mineralized zones and veins, has been brought in from outside the slate series; or it has been derived by circulating ground waters from this formation itself. The following facts are opposed to the latter view: all the rocks have been highly mineralized, if not by valuable metals, at least by pyrite and pyrrhotite; many of the formations have had large amounts of silica deposited in them, and none have been depleted of this compound; quartz veins are abundant, evidencing a further amount of silica seemingly in excess of what the rocks themselves could have furnished. It seems highly probable, then, that material has been brought in from an extraneous source. But from where? Presumably from the rocks which underlie and adjoin the region.

A few miles west from the Cid district occur areas of coarse-grained igneous rocks, covering many hundred square miles. It has been seen (page 93) that these are later intrusive into the slate formation, and are composed of masses of granitic, dioritic, and other igneous rocks, which are themselves separate intrusions. Among the igneous rocks are found dikes of gabbro intermediate in age between diorite and granite; in the slate series gabbro also occurs as dikes. While it is not intended to correlate the two occurrences as the result of the same intrusion, it is probable that gabbro was introduced into the Cid district during the general period of

[1]Becker, G. F. Gold fields of the Southern Appalachians. U. S. Geol. Survey, 16th Ann. Report, pt. 2 (1895): 42.

[2]Min. pet. Mitth., v. 11 (1890): 319 (Cf. Clarke, F. W. The data of Geo-chemistry, U. S. G. S., Bull. 330 (1908): 585).

[3]Clarke, F. W. The data of Geo-chemistry. U. S. G. S., Bull. 330 (1908): 559.

intrusive igneous activity. But whether this be accepted or not, the gabbro dikes are certainly indicative of a large mass of igneous rock at some distance, from the size of the dikes perhaps not very great, below the district.

There is little or no doubt, then, that at some time following the formation and mashing of the slate series, the district was undermined by a mass of igneous rock. Erosion has planed down sufficiently near this mass to expose its offshoots which were insinuated into the overlying rocks in the form of gabbro dikes. It is known that there was a period of batholithic intrusion into the Piedmont Plateau, during which many hundred cubic miles of igneous rocks were brought so near the surface that planation has now exposed great areas to view. There is no reason to consider the gabbro dikes of the Cid district an independent phenomenon; there is some evidence and it is simpler to consider these a related expression of this period of dominant intrusion.

Given then, a highly silicified and mineralized region, underlain and bordered by batholithic intrusions; and both mineralization and intrusion having clearly taken place between two definite limits (*i. e.,* the development of schistosity and the introduction of diabase dikes), it becomes very probable that the source of the solutions and material was predominantly magmatic. It is believed that water or water vapor, excluded from the cooling igneous masses during a long period, was of such a nature as to carry in solution the various elements and compounds, also contributed by the igneous rocks, which were precipitated in their present position to form silica, pyrite, chalcopyrite, galena, sphalerite, gold, argentite, and perhaps other compounds.

It is not known to what proportional extent, if any, the materials were contributed by the gabbro or by the large granitic masses. From the great amount of silica introduced, and from the acid character of the gangues, it seems likely that the granite was the dominant source. Yet it is by no means impossible, and is indeed probable, that the gabbro also added to the mineral content of the region.

Why so much lead and zinc were deposited at the Silver Hill, Silver Valley, and related mines can not be definitely stated. This is an important question, for these mines are distinctive in character and different from all other mines in the slate belt. Apparently conditions before deposition were the same; for the country rock and structure are not essentially different from what is found at many other mines which contain very little or no galena and blende. Three suggestions occur to the writer, which might serve to explain the preponderance of lead and zinc in the mines of the Silver Hill type; but these are merely suggestions. (1) The solution carried small amounts of lead and zinc. Conditions were such in certain mines as to strain out and deposit these in abundance in the form of sulphides. This is strengthened by the fact that such deposits appear to be replacement deposits. Deposits of auriferous pyrite and chalcopyrite, on the other hand, lacked conditions necessary for the precipitation of galena and blende present in the solutions. (2) The lead and zinc deposits might be nearer the source of the material than deposits of auriferous pyrite and chalcopyrite. Thus galena and sphalerite are deposited first and near the source, together with some chalcopyrite and pyrite. The solutions, impoverished of lead and zinc, deposited at greater distances only the auriferous sulphides of iron and copper. This hypothesis is strengthened by the fact that in the Silver Hill Mine occur "dike" rocks, whose relations have never been accurately described, which may represent contact metamorphic effects and indicate proximity to an igneous mass. (3) A point of difference between the mines of Davidson County and mines in other parts of the slate belt is the occurrence of gabbro in the neighborhood of the former. This suggests that a slight variation in the general magma, which was the source of the material, gave rise to a special type of ore deposit, rich in lead and zinc. In other words, the gabbro gave off solutions containing mostly lead and zinc, whereas the acid igneous rocks contributed chiefly auriferous pyrite and chalcopyrite.

DEPOSITION OF THE ORES.

The manner in which the ores were deposited is an important question. Lack of detailed and exact information concerning the underground features necessitates that its treatment be brief and largely hypothetical.

If the ore-bearing solutions were of magmatic origin, they were undoubtedly at high temperatures and under great pressure at the outset. These would tend to work their way upward into regions of less temperature and pressure, and in so doing would gather into trunk channels of major circulation; though whenever a porous formation was met it is reasonable to suppose that this would act like a sponge and become saturated with the silica-bearing waters. Accordingly the first effect of the mineralizing period was probably the addition of silica to the rock formations, resulting in the high silicification of the region. This may have been accompanied by the widespread impregnation of rocks with pyrite and pyrrhotite.

The silicification of the country rocks would itself effect a change in circulation, and tend to direct the solutions into definite channels, following cleavage planes or joint directions. The more massive rocks at the outset were probably rendered practically impervious to circulation; so that the most vigorous circulation was subsequently confined to the schistose rocks. These, indeed, by virtue of their vertical structures, would tend to direct solutions into definite paths, in the same way in which they controlled the introduction of the gabbro dikes. With this restriction of the field of circulation, the concentration of the rarer components of the solutions was rendered easier; and through a decrease in temperature and pressure, a chemical, mechanical, and catalytic action of the wall rock, and by chemical reactions with solutions of a different nature or from other sources, the formation of mineralized zones became possible. However this may be, it is a fact that practically all the ore deposits are confined to schistose or mashed rocks (*i. e.,* to the limbs of the folds).

It must be remembered that the details given in the two preceding paragraphs are entirely suppositional, and are based upon the further assumption of magmatic origin.

A few words may be added as to the probable mode of formation of the four types of "veins": impregnations, stringer leads, cross veins, and replacement deposits. Formerly it was thought that all true veins were fissure veins, occasioned by the filling of gaping fissures. Recently it has been recognized that growing crystals exert an enormous pressure,[1] and that the pre-existence of fissures is not essential to the formation of veins. It would seem, therefore, that the impregnations and in part the stringer leads might readily be explained by the supposition that the vein material, entering along narrow seams, made a place for itself by the expansion due to crystal growth. This of course is not intended to preclude the possibility of the region having been slightly shattered previous to the mineraliza-

[1]Becker, G. F., and Day, A. L. The linear force of growing crystals. Wash. Acad. Sci., Proc., v. 7 (1905): 283–288.

tion; but it does render unnecessary the conception that great open fissures and imbricating lenticular spaces were formed at the right moment and remained open to receive their filling of vein matter. It is also quite probable that the cross veins represent the filling of joint planes, where circulation has been unusually vigorous and sufficient to push aside the walls to make room for continuous deposition. The so-called replacement deposits are of a different order, and do not necessarily imply pre-existing fissures. Why solutions carrying galena and sphalerite formed veins of a different type from solutions which only deposited auriferous pyrite and chalcopyrite can not be stated.

AGE OF THE ORE DEPOSITS.

The age of the ore deposits can be definitely stated to be Pre-Triassic. The period of deposition was certainly subsequent to the time of folding, and in all probability followed the igneous intrusion of granite and other rocks. Since the slate series was deposited in Pre-Cambrian, or possibly early Paleozoic, and underwent profound changes before subjected to mineralization, it is probable that the period of ore deposition was included in the Paleozoic.

SECONDARY ENRICHMENT.

Since their original deposition, the ore deposits have undergone some degree of alteration near the surface, so as to form in the upper workings of the mines ores of a different kind from those found in the lower levels. These changes are of the greatest importance in the mines of the Silver Hill type. This subject has an important practical bearing; from lack of definite information, it can be treated only in a general way.

Surface waters, carrying oxygen and carbonic acid, attack the outcrops and upper parts of veins. The sulphide ores are oxidized to sulphates, which in turn may be changed to carbonates or oxides. Sulphuric acid and acid salts, formed during the process, assist in further decomposing the ores. The sulphates and other compounds differ in solubility; a separation of the more soluble from the less soluble takes place. The more soluble components are taken into solution by the surface waters and carried down into the vein, where below water level the conditions are such that they are precipitated. Thus, in general, a vein has three parts or zones: an upper or oxidized zone, from which the more soluble components have been leached; a middle or enriched zone, to which the material derived from the upper zone has been added; and a lower or unaltered zone, extending usually to an unknown depth, which has suffered no change since its formation.

The Silver Hill mine is the only mine in which the process described above has been of great moment. In the upper workings of this mine large bodies of carbonate ores (chiefly lead carbonate carrying native silver) have been found. These were formed from the original complex mixture of galena and sphalerite with chalcopyrite, silver, and gold. By a difference in solubility of the oxidized products of these compounds, the zinc and copper largely disappeared from the upper parts of the vein; leaving behind a mass of auriferous and argentiferous cerussite, with subordinate amounts of the oxidized compounds of zinc and copper. The writer can not state how definite this upper oxidized zone is, or to what depth it extends. Previous descriptions make no attempt to discuss secondary enrichment in this mine. Probably, however, it reaches to the depth of about 200 feet. Below this zone occur the undecomposed sulphides. These have doubtless been enriched by the material dissolved from the zone above, but not to any appreciable extent except by the additions of copper and zinc sulphides. Hence the middle "enriched" zone has been enriched by the less valuable components of the ore; so from a practical standpoint, it is probable that the value of the ores below the level of the carbonates will continue with but little change to great depths. The vein has probably not been enriched by lead, silver, or gold.

In veins of the Emmons and Conrad Hill types, it is not believed that secondary enrichment is important from an economic standpoint. Near the surface the ores are chiefly limonite, carrying free gold; but sulphides are found at no great depth. The surface ores are of course caused by the oxidation of the iron salts to limonite, which, with gold, is almost insoluble.

To what degree, if any, the veins have been progressively enriched from their upper extents which have been eroded away, the writer sees no way of determining. This has an important bearing as to the depth to which workable ores may be expected to extend. It is likely, however, that the values encountered at the depths of several hundred feet may be found at much greater depths.

The problem, then, of successfully mining the ores of the slate belt is one that can be solved by careful and economical working, and proper concentrating and milling of low grade ores, whose values seem pretty well established.

CHAPTER VII.

SUMMARY.

ROCKS.

The Cid mining district herein described comprises about 125 square miles of Davidson County, North Carolina. Situated in the central portion of the Piedmont Plateau, it is a part of a great series of volcano-sedimentary rocks, known as the Carolina Slate Belt. The district includes areas of slate, acid tuff, acid volcanic breccia, rhyolite, dacite, andesitic tuffs and breccias, andesite, and dikes of gabbro and diabase. All the rocks, save the last two, range from a massive to a schistose condition, with sericite and greenstone schists as the final result of the extreme mashing respectively of the acid and basic rocks.

The slate is a fine-grained, bluish to greenish rock, composed of varying admixtures of land waste and volcanic ash. It has a widespread extent, forming broad belts of country extending in a northeast direction and alternating with bands of the other rocks.

Interbedded with the slate are found beds of rhyolitic and dacitic tuffs, which vary in size from narrow intercalations to broad belts a mile or so in width. Some of the tuff is so fine grained that its fragmental nature only becomes apparent under the microscope. A part of this has been highly silicified, forming a dense, cherty rock, locally called "gun-flint." The acid fine tuff grades on the one hand into the slate; and on the other, into a coarser facies, the acid coarse tuff, in which angular rock fragments and broken phenocrysts can be plainly seen with the unaided eye. Much of the acid tuff is chistose, and near the Silver Hill Mine a broad belt of this rock has been converted into an area of sericite schists.

The acid volcanic breccia is a very coarse phase of the acid tuff, with a preponderance of fragments over groundmass. It occurs in a broad band extending the length of the area mapped and including Flat Swamp Ridge. With this rock are associated flows of rhyolite; and there is such an intimate gradation between the two as to suggest that a part of the breccia is a phase of the rhyolite brecciated through flowage. The rhyolite is a fine-grained, porphyritic rock, devitrified since its consolidation, and in favorable places exhibits unmistakable signs of its extrusive origin. Its best development is along the crest of Flat Swamp Mountain.

Dacite comprises Kemp Mountain in the northern part of the district, and resembles in appearance the rhyolite. It forms an area of oval outline, representing the exposed portion of a surface flow.

Corresponding to the acid series of tuffs, breccias, and flows and interbedded with them, occur a basic series of analogous volcanic rocks of an andesitic character. The andesitic tuffs and breccias include dark green rocks, composed of visible fragments of various kinds and sizes, and there are both massive and schistose phases of these rocks. They are found passing into greenstone schists as the final result of dynamic metamorphism. These basic fragmental rocks occur widely distributed, both in long, narrow strips and in larger areas of oval and irregular outline.

Andesite is of limited extent, and is represented by both an amygdaloidal and massive phase. It is a dark green, heavy, tough rock, and certain occurrences have a trachytic stamp.

Dikes of gabbro and diabase are abundantly distributed, cutting the other formations. Many of the gabbro dikes are several hundred yards wide and extend for miles. These have been controlled in direction by the dip of the schistosity planes in the rocks into which they have been introduced. The diabase is of Triassic age and cuts all other formations, including the gabbro.

STRUCTURE.

Three lines of evidence; namely, the relation of schistose to massive formations, the nature of the bedding planes so far as preserved, and the surface shapes of the formations; agree in suggesting that the district is made up of large inclined folds, with axial planes dipping steeply to the northwest. The present surface bevels this folded series, exposing the edges and folded tops of numerous intercalations of sedimentary and igneous rocks. Flat Swamp Ridge is considered the trough of a syncline, which extends with the ridge in a northeast direction: the two corresponding anticlines on either side are also included within the district; the one passing to the east of Fairmont and Silver Hill, and the other including Denton and Kemp Mountain.

A great overthrust fault probably extends along the eastern edge of Flat Swamp Ridge, which has cut out the succession of beds appearing on its western slope. Other minor faults possibly exist in the region. The schistosity, jointing, and faulting are believed to be largely the result of the compression which squeezed the region into folds.

ECONOMIC GEOLOGY.

The district includes the Silver Hill, Conrad Hill, Silver Valley, Emmons, Cid, Peters, and Ward mines; with numerous smaller workings and prospects. With the exception of the Gold Hill Mine, the Silver Hill Mine has been more extensively worked than any other mine in the State.

The mines and prospects may be divided into three types, according to the nature of the ores: (1) The Silver Hill type, in which the ores consist of a complex mixture of galena and sphalerite, together with pyrite and chalcopyrite, the whole carrying silver and gold; (2) the Conrad Hill type, in which the ores consist of auriferous pyrite and chalcopyrite, in a gangue of quartz, siderite, and hematite; and (3) the Emmons type, in which the ores consist of auriferous pyrite and chalcopyrite in a quartzose gangue, or as narrow stringers in the schists with little or no gangue.

The "veins" may be grouped into four classes: impregnations of ore in the schists; stringer leads, ranging from intricating stringers and lenses of quartz to well-defined quartz veins, and agreeing in trend with the schistosity or cutting that structure at small angles; cross veins, or well-defined quartz veins, which cut the schistosity at large angles and are usually barren; and replacement deposits, or zones carrying seams and lenses of ore, chiefly argentiferous and auriferous galena and sphalerite, in an extremely metamorphosed or highly silicified country rock.

The ore deposits are believed to be of magmatic origin. The great mass of igneous rock which came to place near the district, as indicated by the igneous belt a few miles to the west and the presence of large gabbro dikes within the district, is competent to contribute solutions carrying the silica and ores, with which the region has been impregnated.

APPENDIX.

BIBLIOGRAPHY OF THE CID MINING DISTRICT.

Ayres, Stephen

A desription of the region in North Carolina where gold has been found.
Med. Repos. v., 10 (1807): 148–151.

Balch, William Ralston

Mines and mining interests of North Carolina in 1882.
(*In his* Mines, miners, and mining interests of the United States in 1882. pp. 6; 57–58; 61; 120–127; 1102–1105).

Becker, George Ferdinand

Gold fields of the Southern Appalachians.
(In U. S. Geol. Survey, 16th Ann. Rept., pt. 3. 1895).

Beckwith, John

A memoir on the natural walls or solid dikes in the state of North Carolina.
Am. Jour. Sci., Ser. I, v. 5 (1822): 1–7.

Blake, William Phipps

Silver glance from North Carolina.
Min. Mag., Ser. II, v. 1 (1860): 480.

Silver Hill mine of North Carolina.
(*In his* Silver ores and silver mines. New Haven. 1861. pp. 67–68).

Booth, James Curtis

Analyses of various ores of lead, silver, copper, zinc, iron, etc., from King's mine, Davidson County, North Carolina.
Am. Jour. Sci., Ser. I, v. 41 (1841): 348–352.

Boyd, Charles Rufus

Conrad Hill, N. C., gold and copper mines.
The Virginias, v. 3 (1882): 176.

Campbell, H. D., & Brown, W. G.

Composition of certain mesozoic igneous rocks of Virginia.
Geol. Soc. Am., Bull., v. 2 (1891): 339–347.

Cobb, Collier

A new Paleotrochis locality, with some notes on the nature of Paleotrochis.
Elis. Mit. Sci. Soc., Jour., v. 20 (1904): 11–12.

Cooper, Thomas

Floetz trap in North Carolina.
Am. Jour. Sci., Ser. I, v. 4 (1822): 241.

Diller, Joseph Silas

Origin of Paleotrochis.
Elis. Mit. Sci. Soc., Jour., v. 16 (1899): 59–67.

EATON, AMOS

The gold of the Carolinas in talcose slate.
Am. Jour. Sci., Ser. I, v. 18 (1830): 50–52.

EATON, HARRY NELSON

Micro-structure and probable origin of flint-like slate near Chapel Hill, North Carolina.
Elis. Mit. Sci. Soc., Jour., v. 24 (1908): 1–8.

EMMONS, EBENEZER

American geology, containing a statement of the principles of the science, with full illustrations of the characteristic American fossils.
Albany. Sprague & Co. 1855.

Geological report of the midland counties of North Carolina.
N. C. Geol. Survey. 1856.

On new fossil corals from North Carolina.
Am. Jour. Sci., Ser. II, v. 22 (1856): 389–390.

GENTH, FREDERICK AUGUSTUS

Contributions to mineralogy.
Am. Jour. Sci., Ser. II, v. 16 (1853): 81–86.
Am. Jour. Sci., Ser. II, v. 19 (1855): 15–23.
Am. Jour. Sci., Ser. II, v. 45 (1868): 305–321.

Minerals of North Carolina.
(Appendix *c* to Kerr, W. C., Rept. Geol. Survey of North Carolina. Raleigh, 1875).

On the mineral resources of North Carolina.
Frank. Inst. Jour., v. 63 (1872): 48–61; 114–130.

The minerals of North Carolina.
U. S. Geol. Survey. Bull. 74. 1891.

GOLD AND SILVER PRODUCED BY THE MINES OF AMERICA FROM 1492–1848.
Min. Mag., Ser. I, v. 1 (1853): 365–373.

GOLD MINES IN NORTH CAROLINA.
Am. Jour. Sci., Ser. I, v. 16 (1829): 360–363.

GRATON, LEWIS CARYL

A reconnaissance of some gold and tin deposits of the Southern Appalachians
U. S. Geol. Survey. Bull. 293 (1906).

HALL, JAMES

An account of a supposed artificial wall discovered under the surface of the earth in North Carolina. In a letter to James Woodhouse (and Dr. Woodhouse's reply).
Med. Repos., v. 2 (1799): 272–278.

HANNA, GEORGE BYRON

Mines of the Appalachian ranges.
Sch. of Mines Quart., v. 3 (1882): 208–211.

HIDDEN, WILLIAM EARLE

A new meteoric iron from North Carolina.
Am. Jour. Sci., Ser. III, v. 20 (1880): 324–326.

HITZ, JOHN

To the president and directors of the Washington Mining Company.

HODGE, JAMES T.

The boulders and deposit gold mines of North Carolina.
Assoc. Am. Geol. and Nat., Repts. of 1st, 2d, and 3d meet. (1841): 34–35.

HUNT, THOMAS STERRY

A historical account of the taconic question in geology, with a discussion of the relations of the taconic series to the older crystalline rocks.
Roy. Soc. Can., Trans., v. I, Sec. 4 (1883): 217-270, v. 2, Sec. 4. (1884): 125-157.

JACKSON, CHARLES THOMAS

Report on the Conrad Hill gold mine, Davidson County, North Carolina.
Min. Mag., Ser. I, v. 2 (1854): 190–191.

JOHNSON, WALTER ROGERS

Some observations on the gold formations of Maryland, Virginia, and North Carolina.
Am. Assoc. Adv. Sci., Proc., 4th meet. (1850): 20–21.

KERR, W. C., AND HANNA, G. B.

Ores of North Carolina: being chapter II of the second volume of the geology of North Carolina.
N. C. Geol. Survey. Raleigh (1888).

KERR, WASHINGTON CARUTHERS

Report of the Geological Survey of North Carolina.
1875.

Some peculiarities in the occurrence of gold in North Carolina.
Am. Inst. Min. Eng., Trans., v. 10 (1882): 475–476.

KERR, W. C., AND GENTH, F. A.

The minerals and mineral localities of North Carolina: being chapter I of the second volume of the geology of North Carolina.
N. C. Geol. Survey, Raleigh (1881).

KUNZ, GEORGE FREDERICK

Native silver in North Carolina.
Am. Jour. Sci., Ser. IV, v. 7 (1899): 242–243.

LANEY, FRANCIS BAKER

The Gold Hill mining district of North Carolina.
N. C. Geological and Economic Survey, Bull. 21, 1910.
A Thesis. Yale University (1908).

Laney, F. B., and Pogue, J. E., Jr.

An outcrop map of the Virgilina copper district. Scale 1: 24000.
N. C. Geol. Survey (1908).

Lyon, Edward West

The Progress of gold mining in North Carolina.
Eng. and Mg. Jour., v. 87 (1909): 293–297.

Leeds, Stephen P.

Gold ores and their workings.
Min. Mag., Ser. I, v. 7 (1856): 23–32; 265–275; 344–356; 445–453.

Notes on the gold regions of North and South Carolina.
Min. Mag., Ser. I, v. 2 (1854): 27–34; 357–399.

Leidy, Joseph

Remarks on Paleotrochis.
Acad. Nat. Sci. Phil., Proc., v. 1 (1859): 150.

Lewis, Zechariah

Remarks on a subterranean wall in North Carolina.
Med. Repos., v. 4 (1801): 227–234.

Letters on a subterranean wall in North Carolina.
Med. Repos., v. 5 (1802): 397–407.

Lindgren, Waldemar

Orthoclase as gangue material in a fissure vein.
Am. Jour. Sci., Ser. IV, v. 5 (1898): 418–420.

Marsh, Othniel Charles

On the Paleotrochis of Emmons from North Carolina.
Am. Jour. Sci., Ser. II, v. 45 (1869): 217–219.

Mitchell, Elisha

Elements of geology; with an outline of the geology of North Carolina. 1842.

On the geology of the gold region of North Carolina.
Am. Jour. Sci., Ser. I, v. 16 [1829] : 1–19.

Report on the geology of North Carolina, conducted under Board of Agriculture.
Pt. 3. Raleigh (1827).

Moore, Frederick

Gold in North Carolina.
Sci. Am. Suppl., v. 53 (1902): 218–219.

Nitze, Henry Benjamin Charles

Gold Mining in the Southern States.
Engineering, v. 10 (1896): 821–844.

Some late views on the so-called taconic and huronian rocks of North Carolina.
Elis. Mit. Sci. Soc., Jour., v. 13 (1896): 53–72.

The genesis of the gold ores in the central slate belt of the Carolinas.
Eng. and Mg. Jour., v. 63 (1897): 628–629.

NITZE, H. B. C., AND HANNA, G. B.
Gold deposits of North Carolina.
N. C. Geol. Survey, Bull. 3 (1896).

NITZE, H. B. C., AND WILKINS, H. A. J.
Gold mining in North Carolina and adjacent South Appalachian regions.
N. C. Geol. Survey, Bull. 10 (1897).
The present condition of gold mining in the Southern Appalachian states.
Am. Inst. Min. Eng., Trans., v. 25 (1895): 661–796.

OLMSTED, DENISON
On the gold mines of North Carolina.
Am. Jour. Sci., Ser. I, v. 9 (1825): 5–15.
Report on the geology of North Carolina, conducted under the Board of Agriculture. Raleigh (1825–27).
Paleotrochis of Emmons.
Am. Jour. Sci., Ser. II, v. 23 (1857): 278.
Am. Jour. Sci., Ser. II, v. 24 (1857): 151.

PETHERICK, THOMAS
Report upon the Silver Hill mine, Davidson County, North Carolina.
In Report of the Silver Hill Mining Co., New York (1860): 8–11.

POGUE, JOSEPH E., JR.
Geology and structure of the ancient volcanic rocks of Davidson County, North Carolina.
Am. Jour. Sci., Ser. IV, v. 28 (1909): 218–238.
On Olivine-diabase from Davidson County, North Carolina.
Proc. U. S. Nat. Museum, v. 37 (1910): 475–484.

PRATT, JOSEPH HYDE
Mining industry in North Carolina during 1900 (also 1901, 1902, 1903, 1904, 1905, 1906).
N. C. Geol. Survey. Econ. Papers No. 6, 7, 8, 9, 11, 14, 15.

PRATT, J. H., AND STEEL, A. A.
Recent changes in gold mining in North Carolina.
In Mining industry in North Carolina during 1906. N. C. Geol. Survey, Econ. Paper No. 14: 19–82.

REPORT OF THE DIRECTOR OF THE MINT upon the statistics of the production of the precious metals in the United States.
Washington (1880–1904).

ROBINSON, SAMUEL
Catalogue of minerals from North Carolina.
In his Catalogue of American minerals with their localities. Boston (1825): 210–220.

ROGERS, HENRY DARWIN
Classification of the metamorphic strata of the Atlantic slope of the middle and southern states.
Bost. Soc. Nat. Hist., Proc., v. 6 (1859): 140–145.

ROTHE, CHARLES E.
Remarks on the gold mines of North Carolina.
Am. Jour. Sci., Ser. I, v. 13 (1828): 201–217.

TAYLOR, RICHARD COWLING.

Report on the Washington silver mine, Davidson County, North Carolina. 1845.

TENNY, WILLIAM J.

The Conrad Hill mine, Davidson County, North Carolina. Min. Mag., Ser. I, v. 1 (1853): 628.

The Silver Hill mine, North Carolina. Min. Mag., Ser. II, v. 1 (1860): 368-371.

VAN HISE, CHARLES RICHARD.

Archaean and Algonkian. U. S. Geol. Survey, Bull. 86 (1892).

WATSON, THOMAS LEONARD.

Copper-bearing rocks of Virgilina copper district, Virginia and North Carolina. Geol. Soc. Am., Bull. v. 13 (1902): 353-376.

WEED, WALTER HARVEY.

Copper deposits of the Appalachian States. U. S. Geol. Survey, Bull. 213 (1902).

Notes on the Carolina gold deposits. Eng. and Mg. Jour., v. 72 (1901): 494.

Types of copper deposits in the southern United States. Am. Inst. Mg. Eng., Trans., v. 30 (1900): 449-504.

WEED, W. H., AND WATSON, T. L.

The Virginia copper deposits. Econ. Geol., v. 1 (1906): 309–330.

WHITS, CHARLES HENRY

An examination into the nature of Paleotrochis. Elis. Mit. Sci. Soc., Jour., v. 11 (1894): 50–66.

WHITNEY, JOSIAH DWIGHT

The metallic wealth of the United States described and compared with other countries. Philadelphia (1854).

WILLIAMS, GEORGE HUNTINGTON

Ancient volcanic rocks along the eastern border of North America. Am. Geol., v. 13 (1894): 212–213.

The distribution of ancient volcanic rocks along the eastern border of North America (with map). Jour. Geol., v. 2 (1894): 1–31.

WOODHOUSE, JAMES

Remarks on a letter of the Rev. Zechariah Lewis relating to a subterranean wall discovered in North Carolina. Med. Repos., v. 5 (1802): 21-24.

Additional observations on the subterranean minerals near the Yadkin in North Carolina. Med. Repos., v. 7 (1804): 26-27.

PUBLICATIONS

OF THE

North Carolina Geological and Economic Survey.

BULLETINS.

1. Iron Ores of North Carolina, by Henry B. C. Nitze, 1893. 8°, 239 pp., 20 pl., and map. *Postage 10 cents.*

2. Building and Ornamental Stones in North Carolina, by T. L. Watson and F. B. Laney in collaboration with George P. Merrill, 1906. 8°, 283 pp., 32 pl., 2 figs. *Postage 25 cents. Cloth-bound copy 30 cents extra.*

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4. Road Material and Road Construction in North Carolina, by J. A. Holmes and William Cain, 1893. 8°, 88 pp. *Out of print.*

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21. The Gold Hill Mining District of North Carolina, by Francis Baker Laney 1910. 8°, 137 pp., 23 pl., 5 figs. *Postage 15 cents.*

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Gives a List of Minerals found in North Carolina; describes the Treatment of Sulphuret Gold Ores, giving Localities; takes up the Occurrence of Copper in the Virgilina, Gold Hill, and Ore Knob districts; gives Occurrence and Uses of Corundum; a List of Garnets, describing Localities; the Occurrence, Associated Minerals, Uses and Localities of Mica; the Occurrence of North Carolina Feldspar, with Analyses; an extended description of North Carolina Gems and Gem Minerals; Occurrences of Monazite, Barytes, Ocher; describes and gives Occurrences of Graphite and Coal; describes and gives Occurrences of Building Stones, including Limestone; describes and gives Uses for the various forms of Clay; and under the head of Other Economic Minerals" describes and gives Occurrences of Chromite, Asbestos, and Zircon.

7. Mining Industry in North Carolina During 1902, by Joseph Hyde Pratt, 1903. 8°, 27 pp. *Postage 2 cents.*

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11. The Mining Industry in North Carolina During 1905, by Joseph Hyde Pratt, 1906. 8°, 95 pp. *Postage 4 cents.*

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VOLUMES.

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